FIG.1

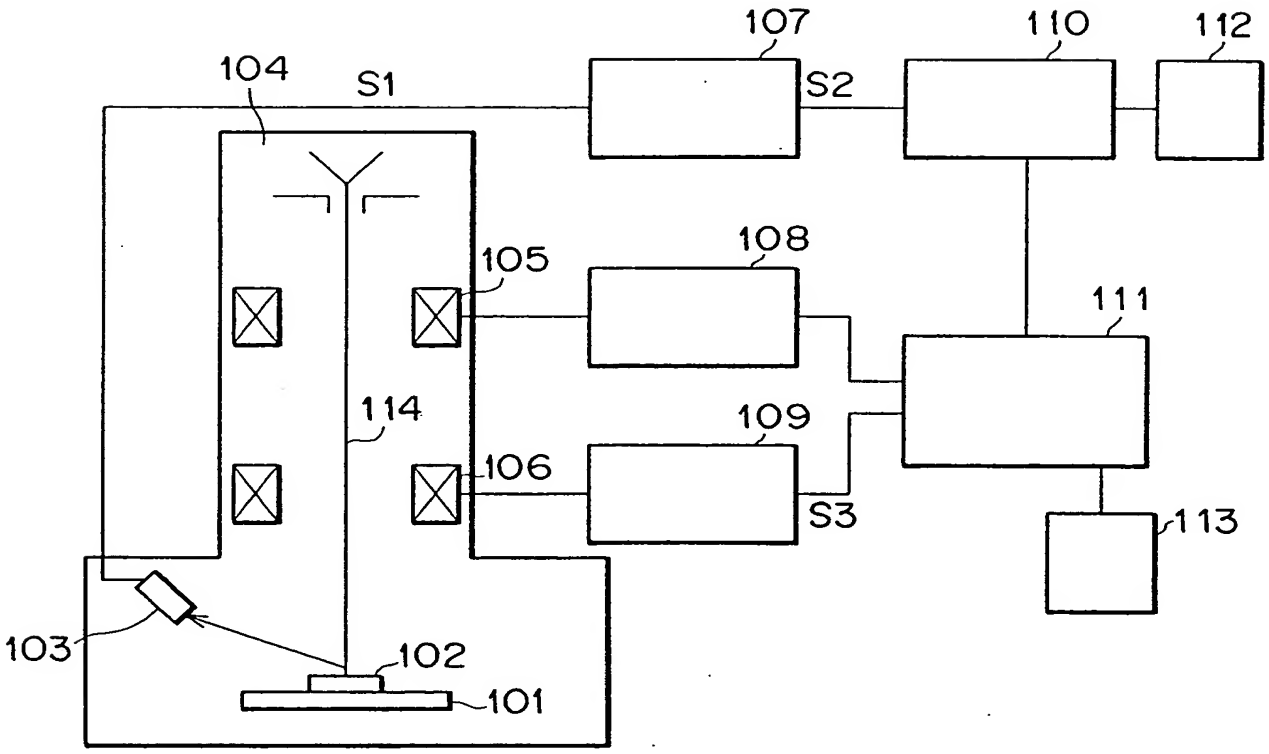


FIG. 2

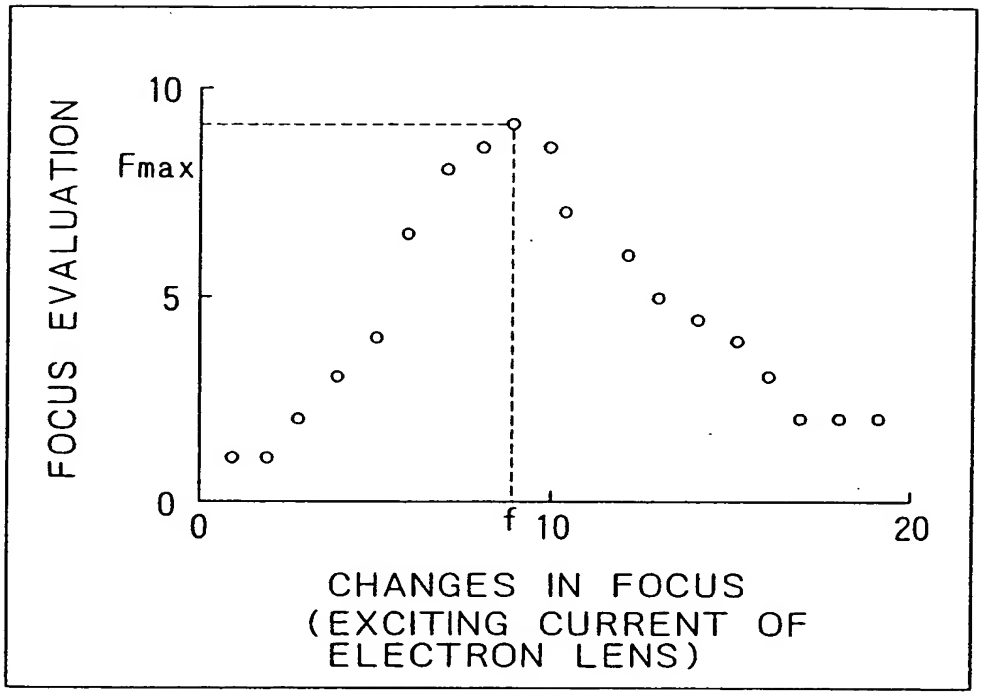

FOCUS EVALUATION
10
Fmax
5
0
0
f
10
20
CHANGES IN FOCUS
(EXCITING CURRENT OF
ELECTRON LENS)

FIG. 3

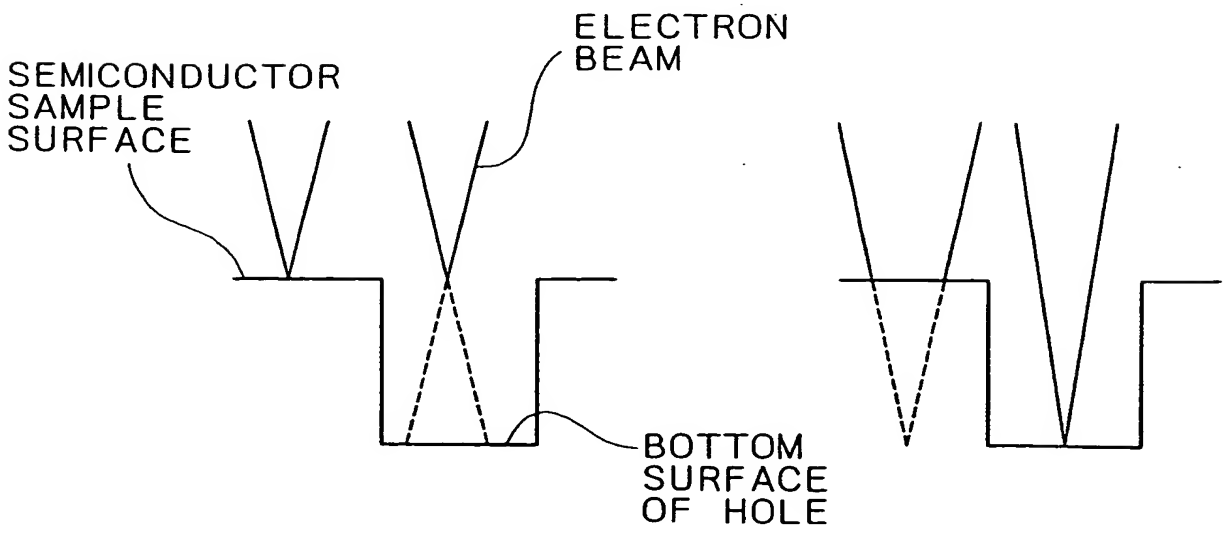

SEMICONDUCTOR
SAMPLE
SURFACE
ELECTRON
BEAM
BOTTOM
SURFACE
OF HOLE

FIG.4

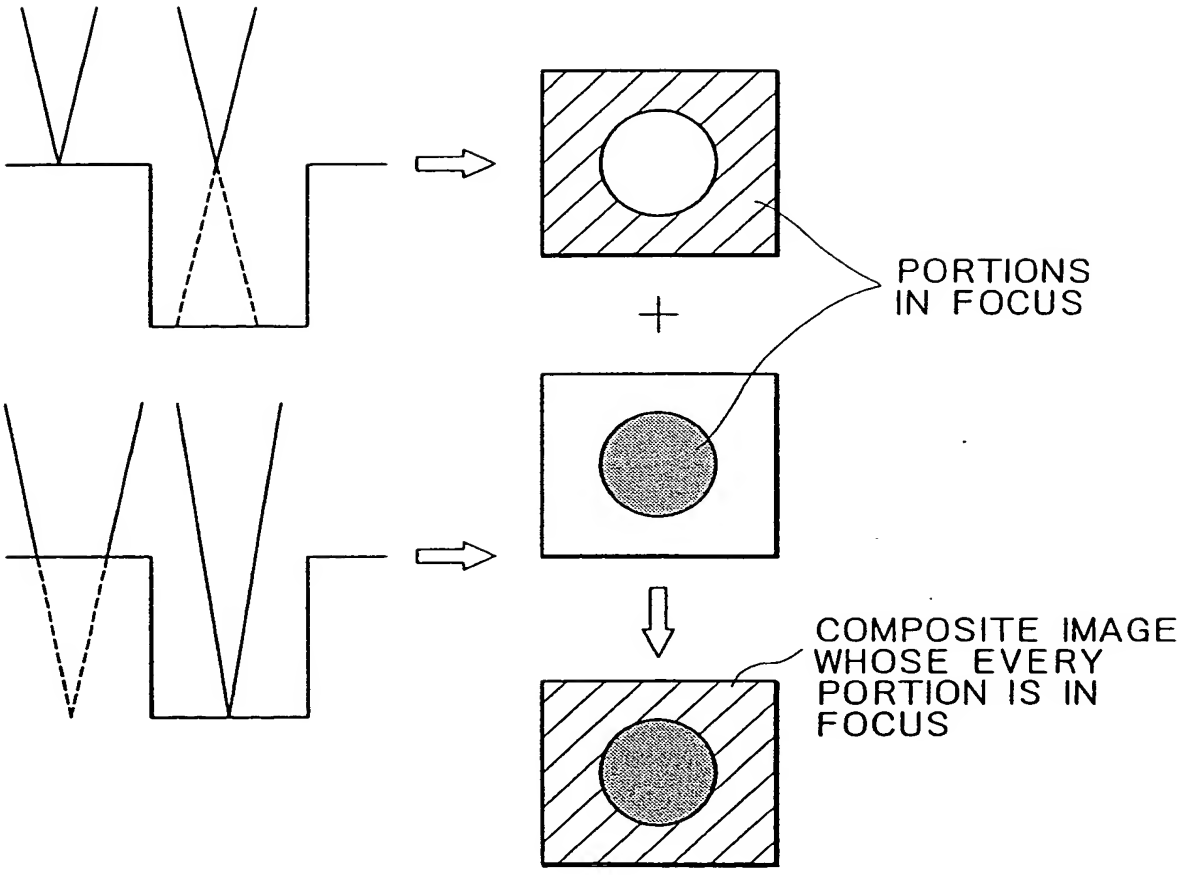

PORTIONS
IN FOCUS
COMPOSITE IMAGE
WHOSE EVERY
PORTION IS IN
FOCUS

FIG. 5

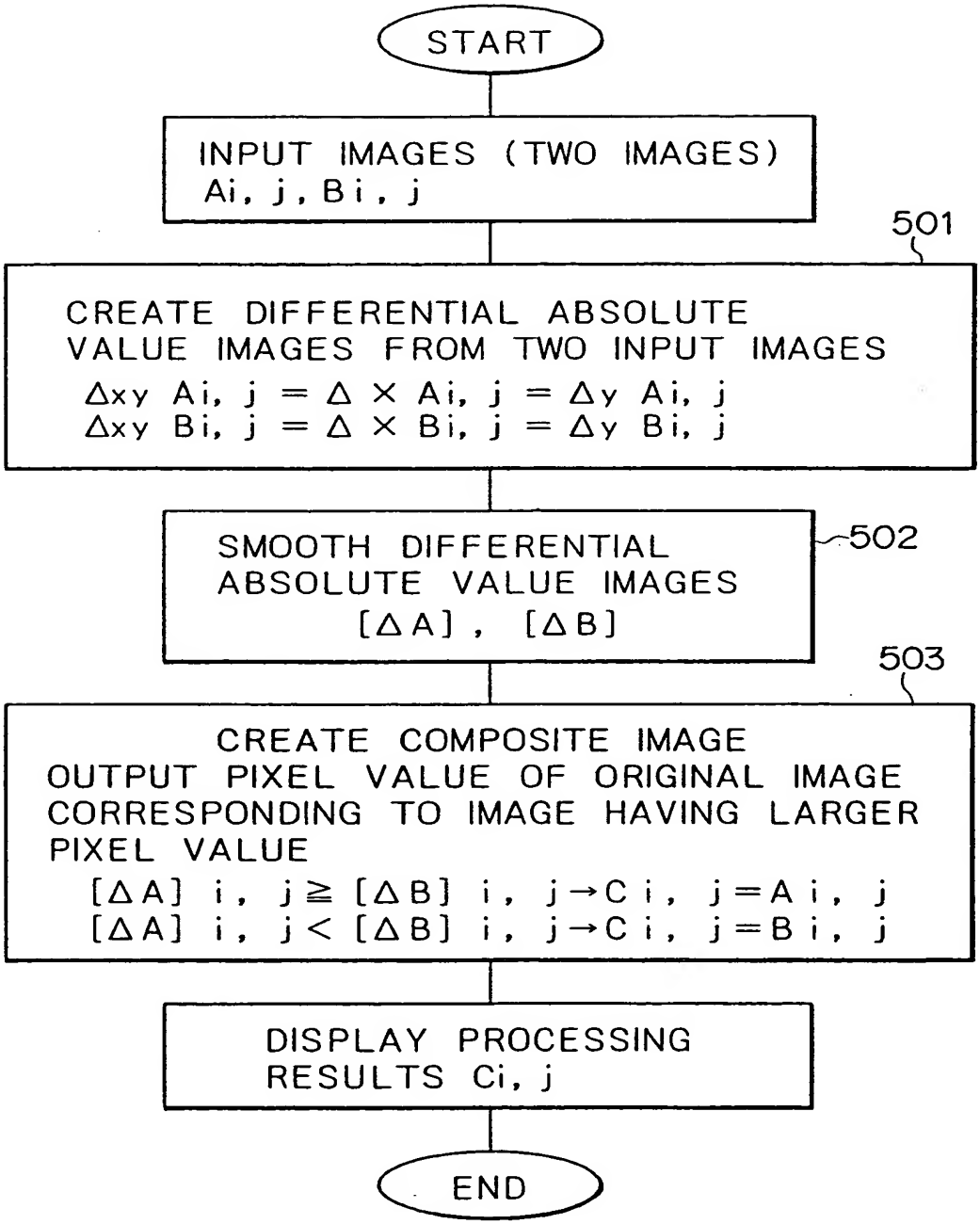

START
INPUT IMAGES (TWO IMAGES)
Ai, j, Bi, j
501
CREATE DIFFERENTIAL ABSOLUTE VALUE IMAGES FROM TWO INPUT IMAGES
Δxy Ai, j = Δ × Ai, j = Δy Ai, j
Δxy Bi, j = Δ × Bi, j = Δy Bi, j
SMOOTH DIFFERENTIAL ABSOLUTE VALUE IMAGES
[ΔA], [ΔB]
502
503
CREATE COMPOSITE IMAGE
OUTPUT PIXEL VALUE OF ORIGINAL IMAGE CORRESPONDING TO IMAGE HAVING LARGER PIXEL VALUE
[ΔA] i, j ≧ [ΔB] i, j → C i, j = A i, j
[ΔA] i, j < [ΔB] i, j → C i, j = B i, j
DISPLAY PROCESSING RESULTS Ci, j
END

FIG. 6

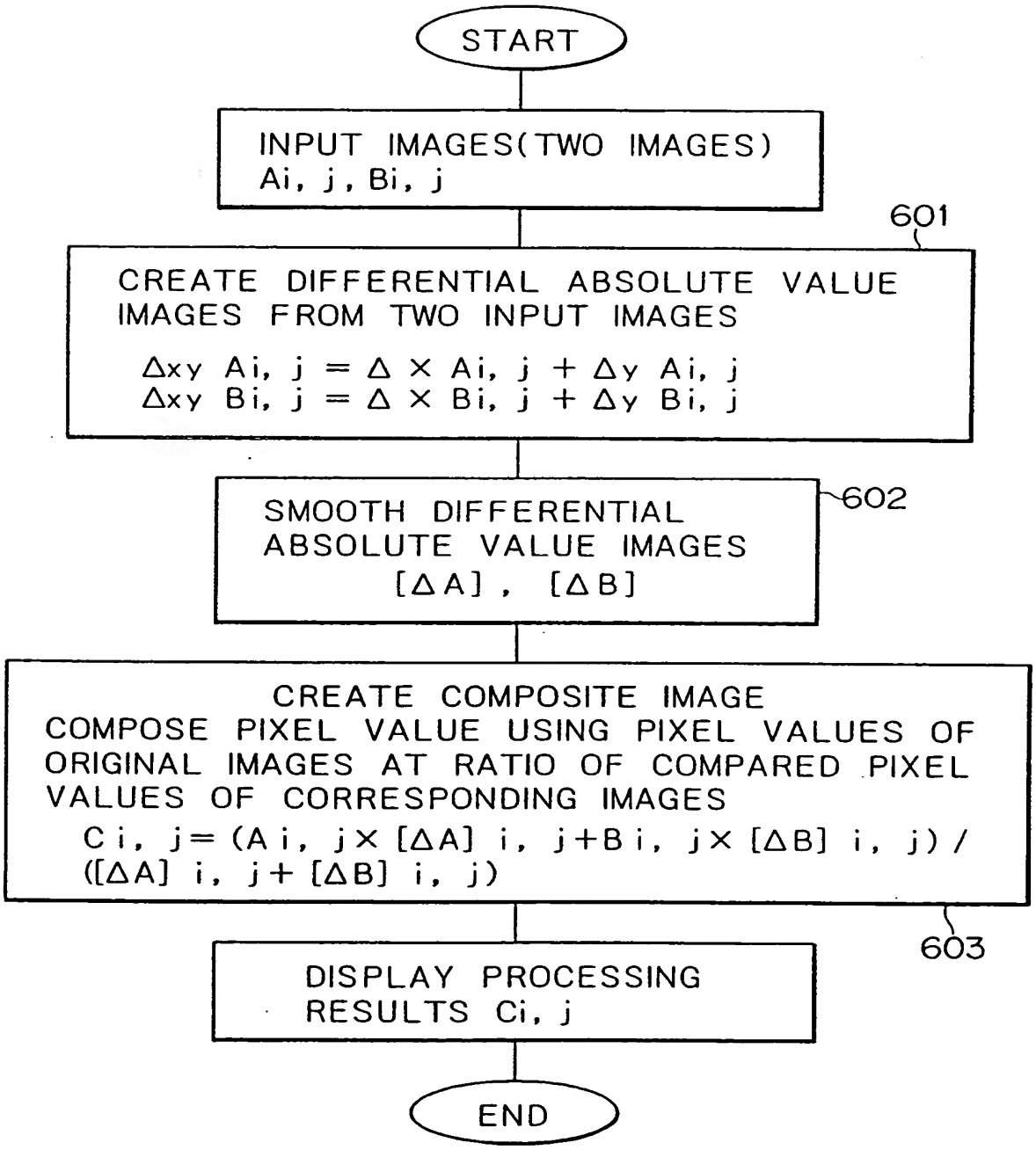

START
INPUT IMAGES(TWO IMAGES)
Ai, j, Bi, j
601
CREATE DIFFERENTIAL ABSOLUTE VALUE IMAGES FROM TWO INPUT IMAGES
Δxy Ai, j = Δ × Ai, j + Δy Ai, j
Δxy Bi, j = Δ × Bi, j + Δy Bi, j
602
SMOOTH DIFFERENTIAL ABSOLUTE VALUE IMAGES
[ΔA], [ΔB]
CREATE COMPOSITE IMAGE
COMPOSE PIXEL VALUE USING PIXEL VALUES OF ORIGINAL IMAGES AT RATIO OF COMPARED PIXEL VALUES OF CORRESPONDING IMAGES
Ci, j = (Ai, j × [ΔA] i, j + Bi, j × [ΔB] i, j) / ([ΔA] i, j + [ΔB] i, j)
603
DISPLAY PROCESSING RESULTS Ci, j
END

FIG. 7

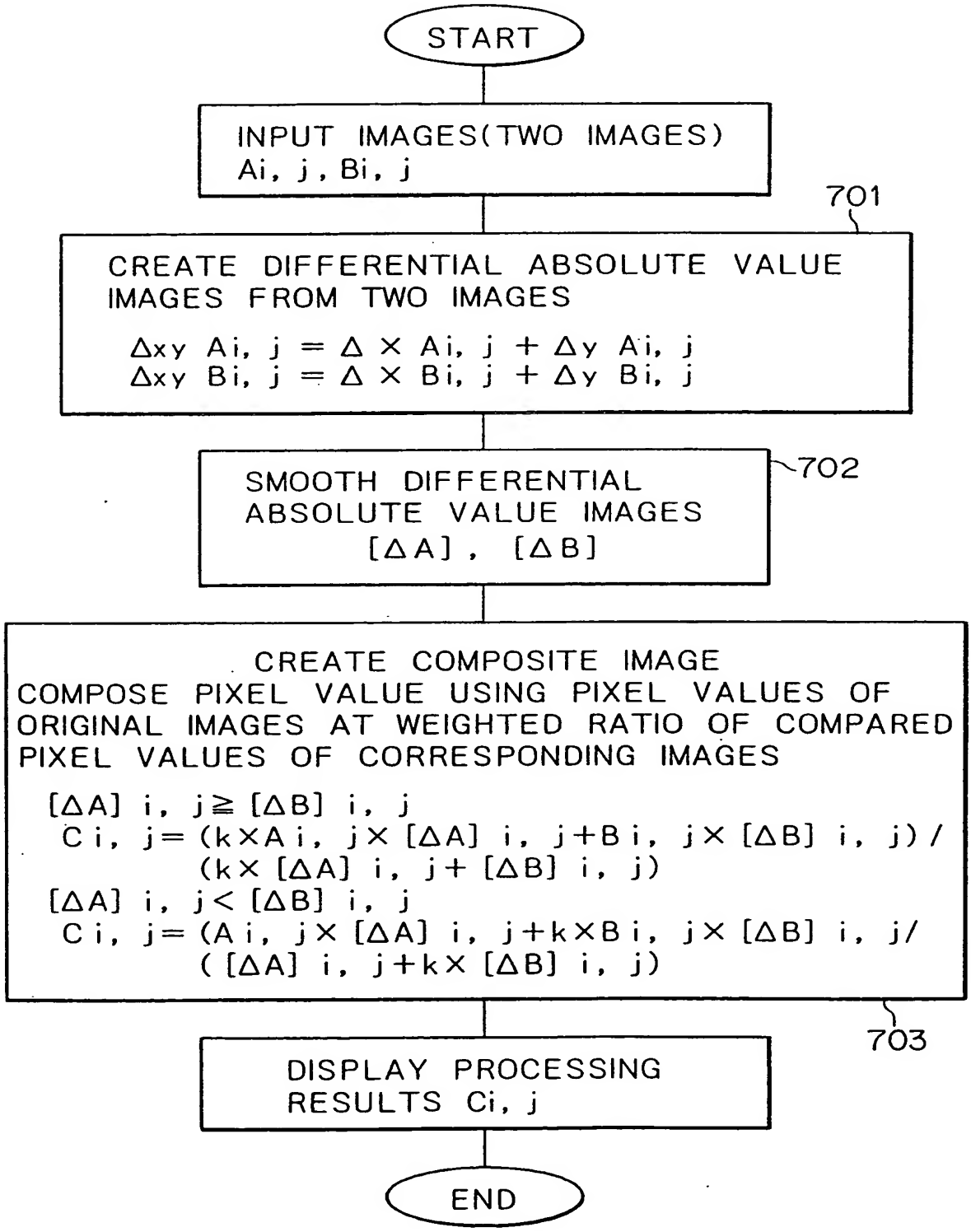

START
INPUT IMAGES(TWO IMAGES)
Ai, j, Bi, j
701
CREATE DIFFERENTIAL ABSOLUTE VALUE IMAGES FROM TWO IMAGES
Δxy Ai, j = Δ × Ai, j + Δy Ai, j
Δxy Bi, j = Δ × Bi, j + Δy Bi, j
SMOOTH DIFFERENTIAL ABSOLUTE VALUE IMAGES
[ΔA], [ΔB]
702
CREATE COMPOSITE IMAGE
COMPOSE PIXEL VALUE USING PIXEL VALUES OF ORIGINAL IMAGES AT WEIGHTED RATIO OF COMPARED PIXEL VALUES OF CORRESPONDING IMAGES
[ΔA] i, j ≧ [ΔB] i, j
Ci, j = (k×Ai, j×[ΔA] i, j+Bi, j×[ΔB] i, j) / (k×[ΔA] i, j+[ΔB] i, j)
[ΔA] i, j < [ΔB] i, j
Ci, j = (Ai, j×[ΔA] i, j+k×Bi, j×[ΔB] i, j / ([ΔA] i, j+k×[ΔB] i, j)
703
DISPLAY PROCESSING RESULTS Ci, j
END

FIG. 8

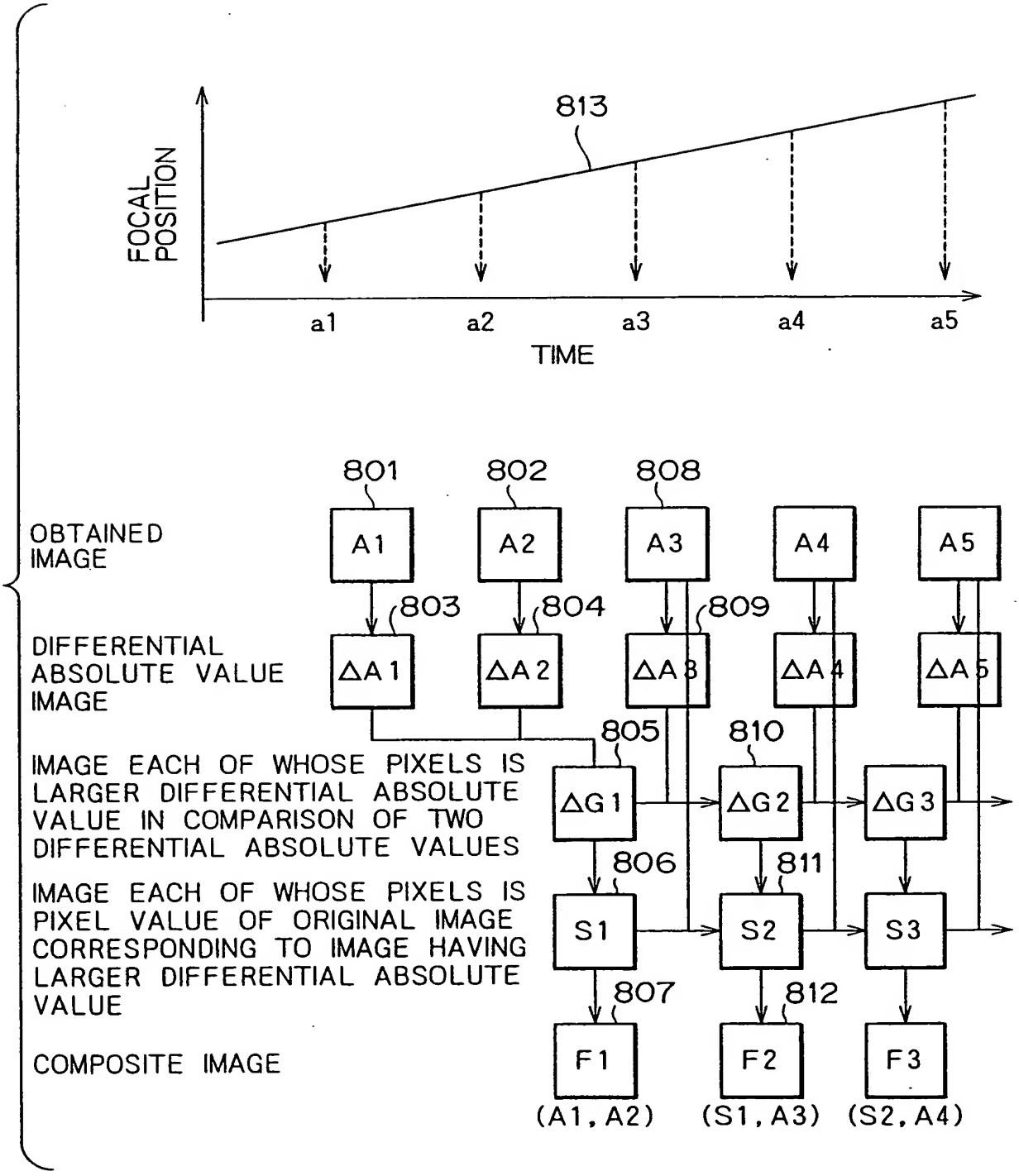

813
FOCAL POSITION
a1
a2
a3
a4
a5
TIME
801
802
808
A1
A2
A3
A4
A5
803
804
809
ΔA1
ΔA2
ΔA3
ΔA4
ΔA5
805
810
ΔG1
ΔG2
ΔG3
806
811
S1
S2
S3
807
812
F1
F2
F3
(A1, A2)
(S1, A3)
(S2, A4)
OBTAINED IMAGE
DIFFERENTIAL ABSOLUTE VALUE IMAGE
IMAGE EACH OF WHOSE PIXELS IS LARGER DIFFERENTIAL ABSOLUTE VALUE IN COMPARISON OF TWO DIFFERENTIAL ABSOLUTE VALUES
IMAGE EACH OF WHOSE PIXELS IS PIXEL VALUE OF ORIGINAL IMAGE CORRESPONDING TO IMAGE HAVING LARGER DIFFERENTIAL ABSOLUTE VALUE
COMPOSITE IMAGE

FIG.9

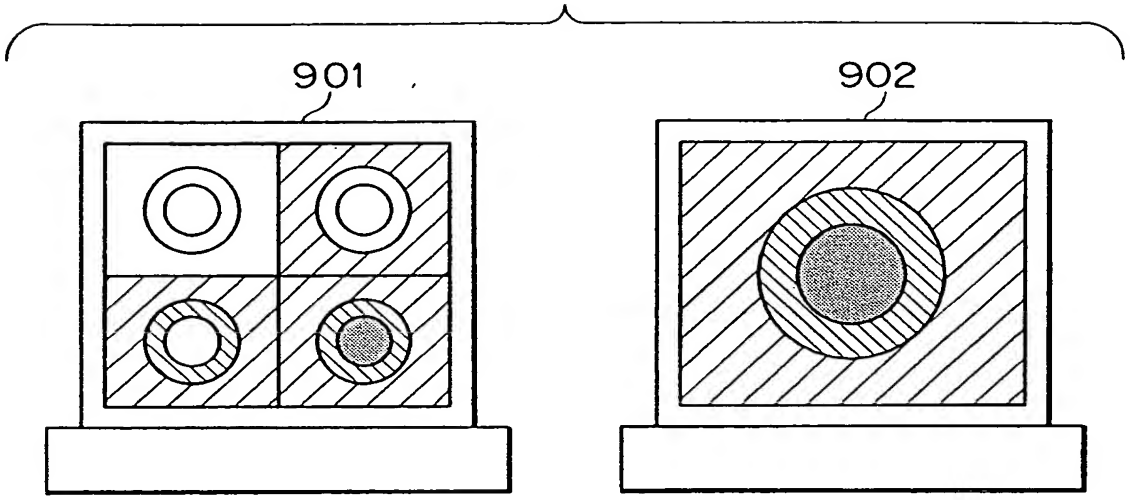


FIG.10

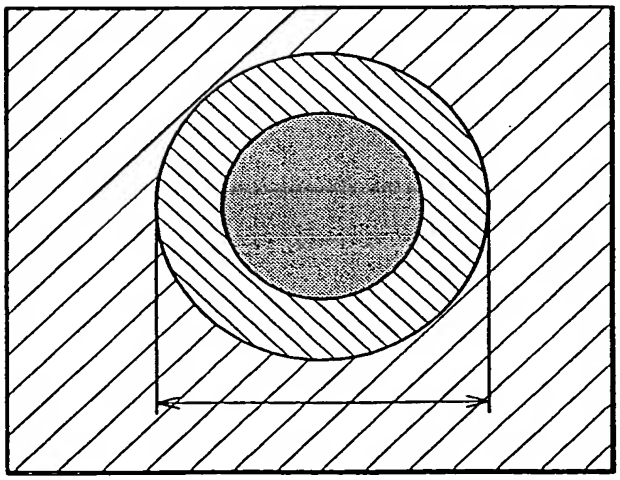


FIG.11

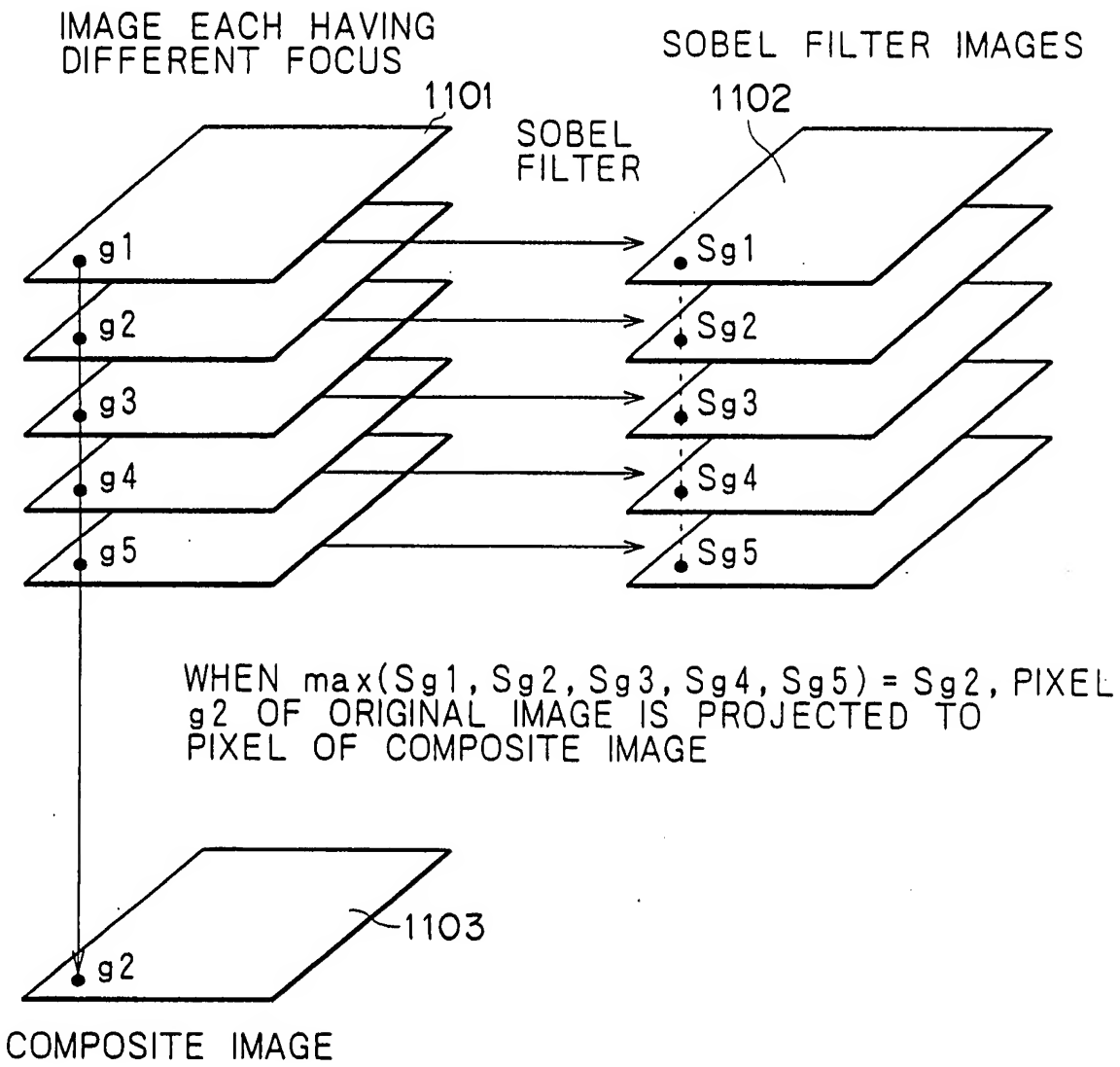


IMAGE EACH HAVING DIFFERENT FOCUS
1101
SOBEL FILTER
SOBEL FILTER IMAGES
1102
g1
g2
g3
g4
g5
Sg1
Sg2
Sg3
Sg4
Sg5
WHEN max(Sg1, Sg2, Sg3, Sg4, Sg5) = Sg2, PIXEL g2 OF ORIGINAL IMAGE IS PROJECTED TO PIXEL OF COMPOSITE IMAGE
1103
g2
COMPOSITE IMAGE

FIG.12

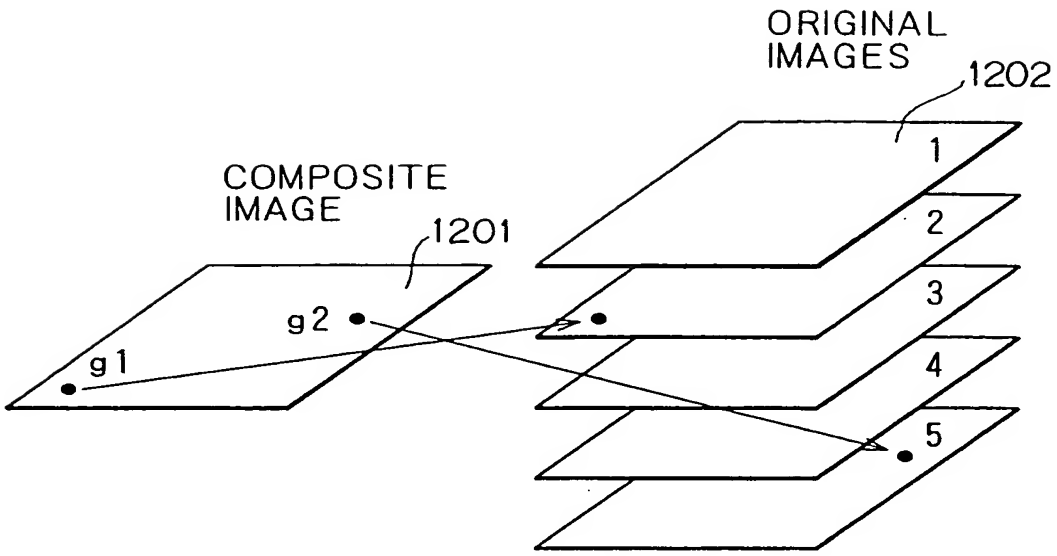

ORIGINAL
IMAGES
1202
1
2
3
4
5
COMPOSITE
IMAGE
1201
g2
g1

FIG.13

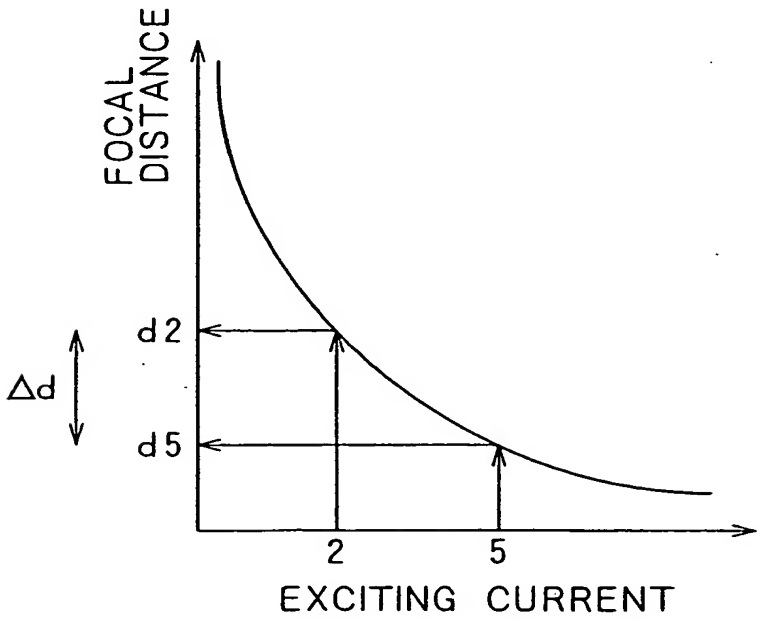

FOCAL
DISTANCE
d2
Δd
d5
2
5
EXCITING CURRENT

FIG.14

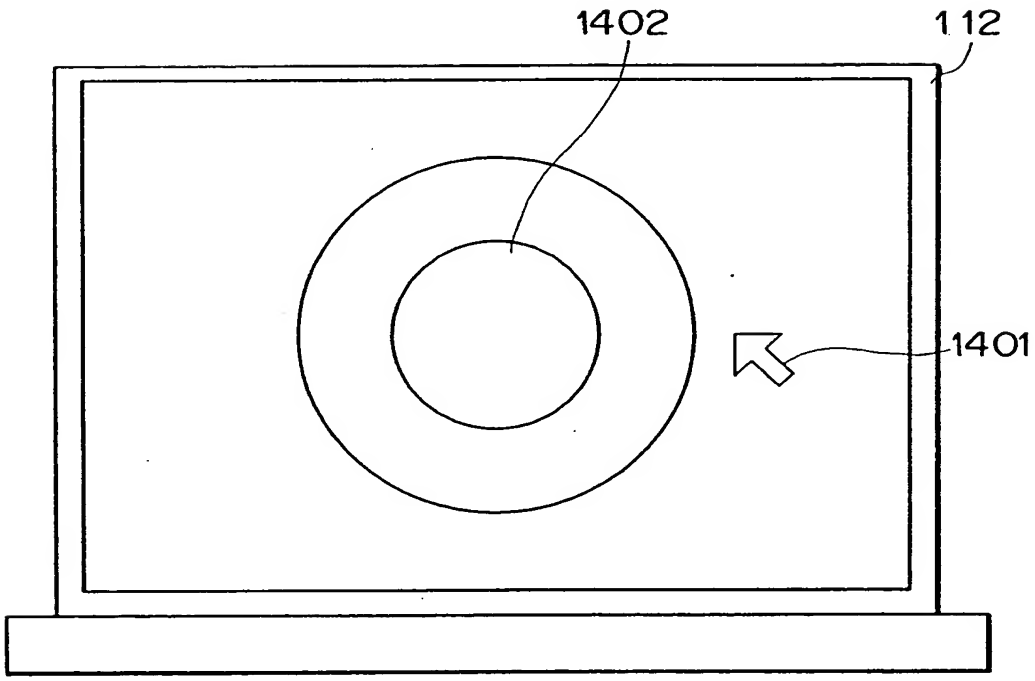


FIG.15

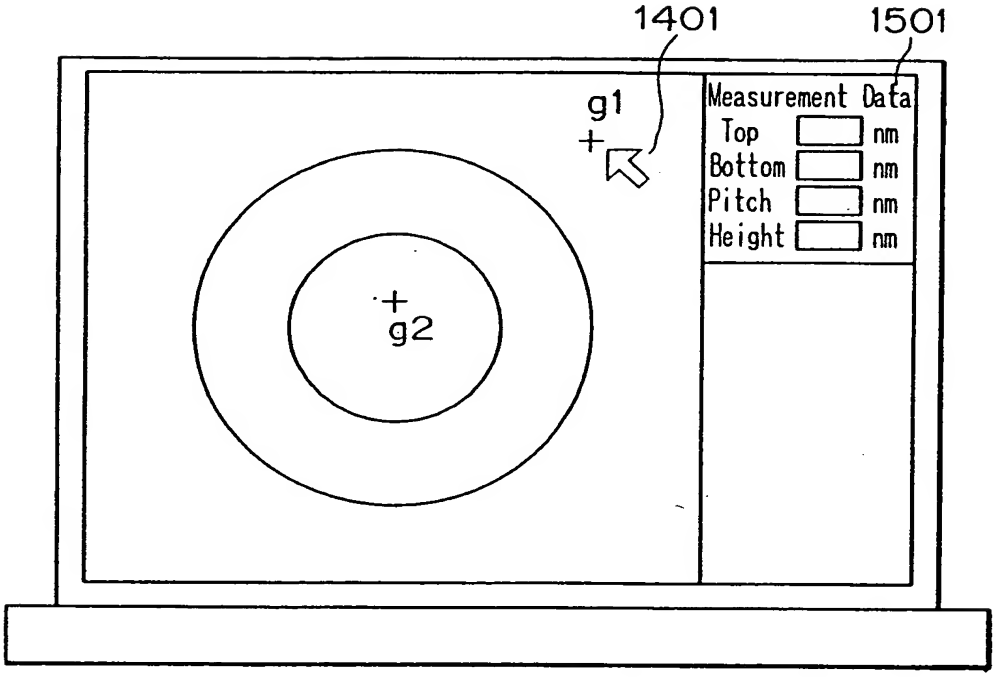

1401
1501
g1
g2
Measurement Data
Top
nm
Bottom
nm
Pitch
nm
Height
nm

FIG.16

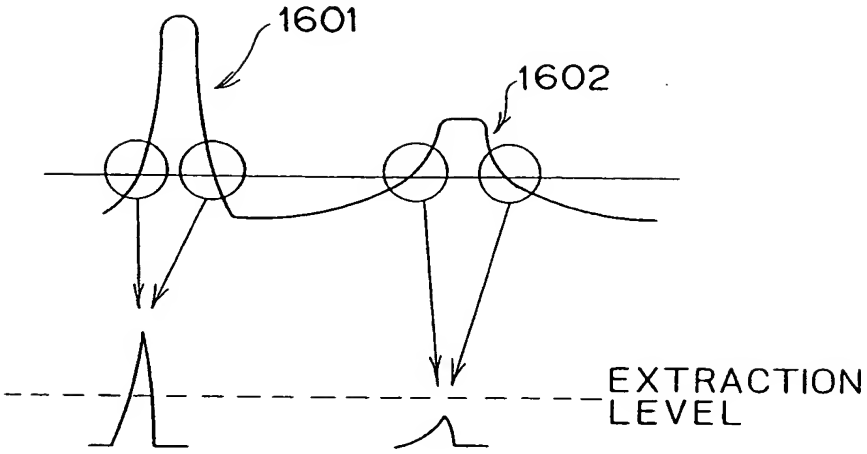

1601
1602
EXTRACTION
LEVEL

FIG.17

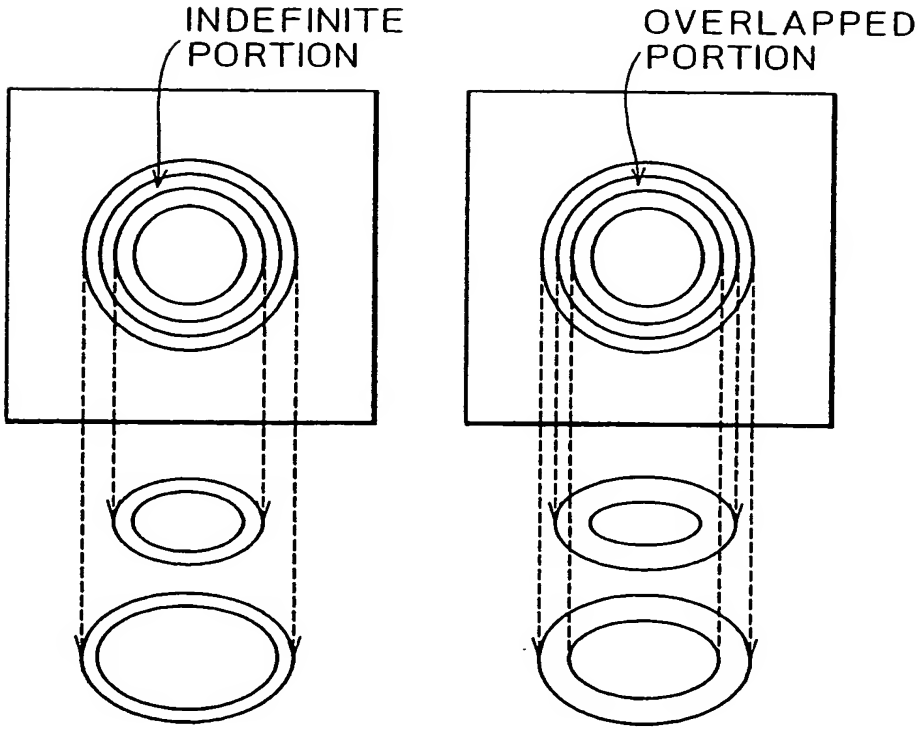

INDEFINITE
PORTION
OVERLAPPED
PORTION

FIG.18

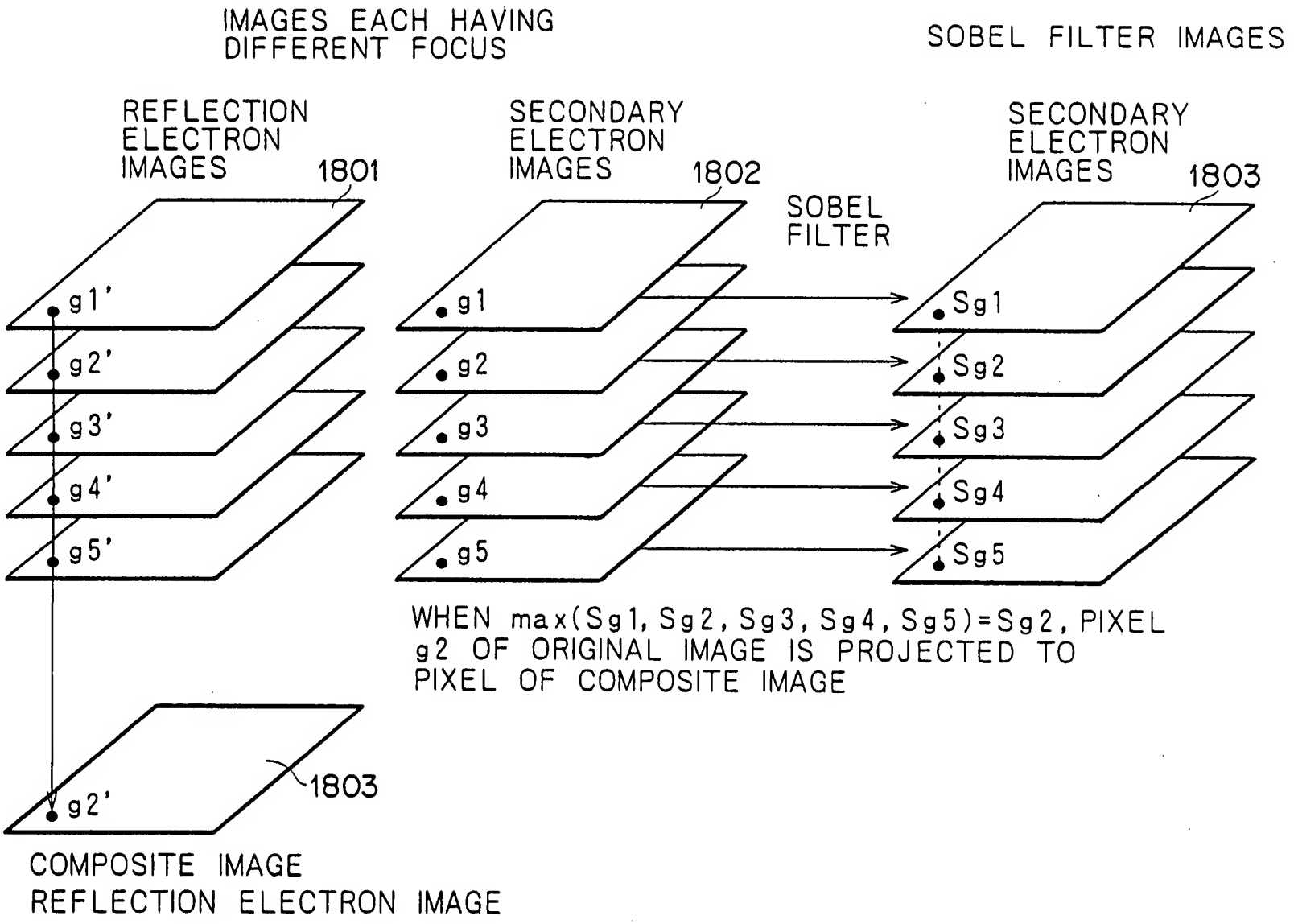
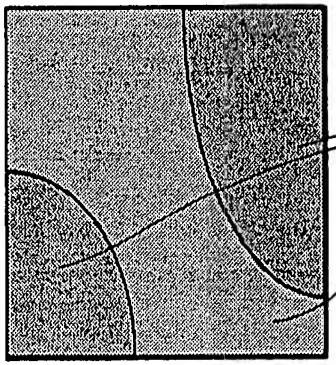

IMAGES EACH HAVING DIFFERENT FOCUS
SOBEL FILTER IMAGES
REFLECTION ELECTRON IMAGES
1801
SECONDARY ELECTRON IMAGES
1802
SOBEL FILTER
SECONDARY ELECTRON IMAGES
1803
g1'
g2'
g3'
g4'
g5'
g1
g2
g3
g4
g5
Sg1
Sg2
Sg3
Sg4
Sg5
WHEN max(Sg1, Sg2, Sg3, Sg4, Sg5)=Sg2, PIXEL g2 OF ORIGINAL IMAGE IS PROJECTED TO PIXEL OF COMPOSITE IMAGE
1803
g2'
COMPOSITE IMAGE
REFLECTION ELECTRON IMAGE

FIG.19



AREAS WHOSE IN-FOCUS DEGREE IS DETERMINED USING REFLECTION ELECTRON IMAGES

AREA WHOSE IN-FOCUS DEGREE IS DETERMINED USING SECONDARY ELECTRON IMAGES

FIG.20

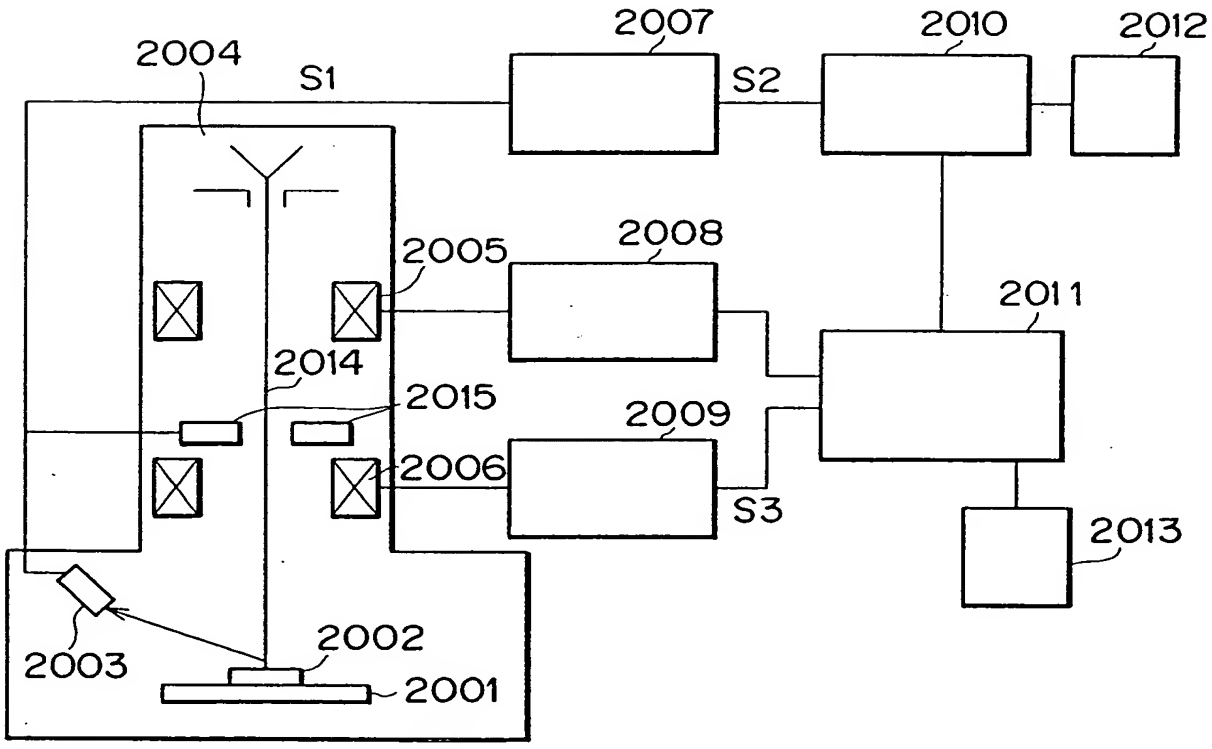
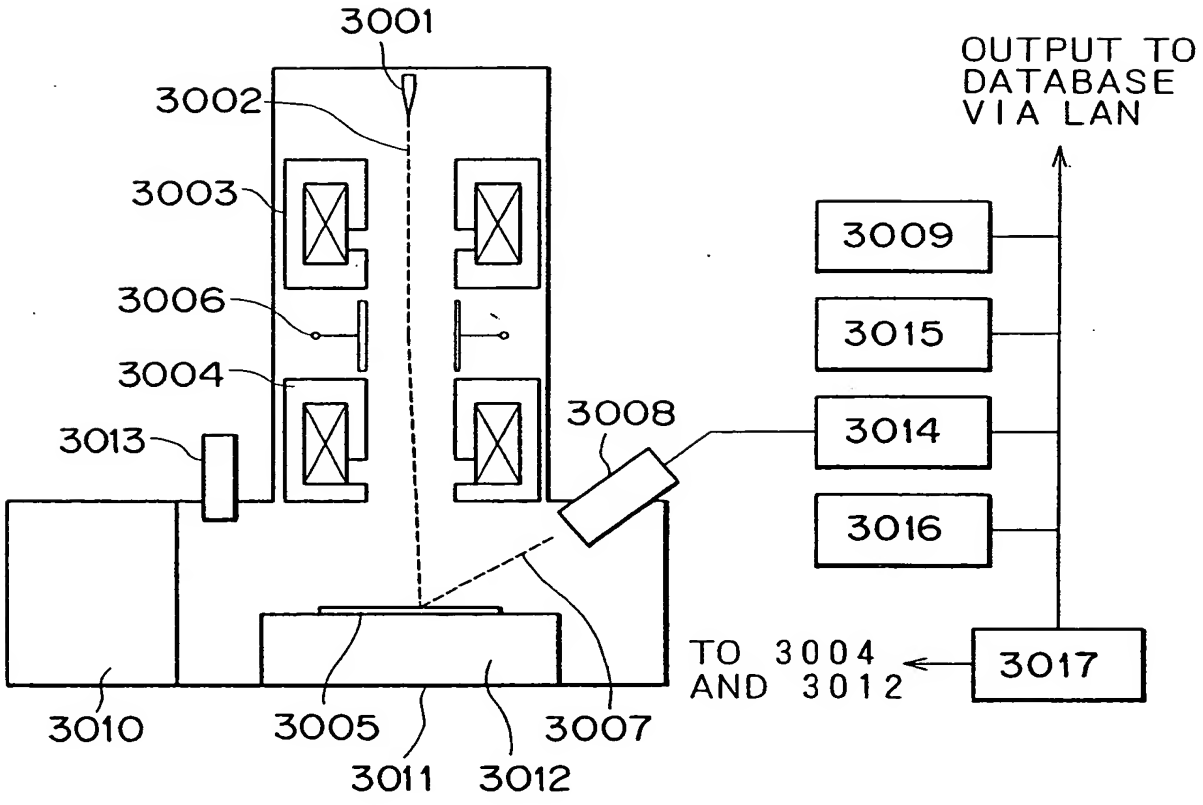

2007
2010
2012
2004
S1
S2
2008
2005
2011
2014
2015
2009
2006
S3
2013
2003
2002
2001

FIG.21


3001
3002
3003
3006
3004
3013
3008
3009
3015
3014
3016
OUTPUT TO DATABASE VIA LAN
TO 3004 AND 3012
3017
3010
3005
3011
3012
3007

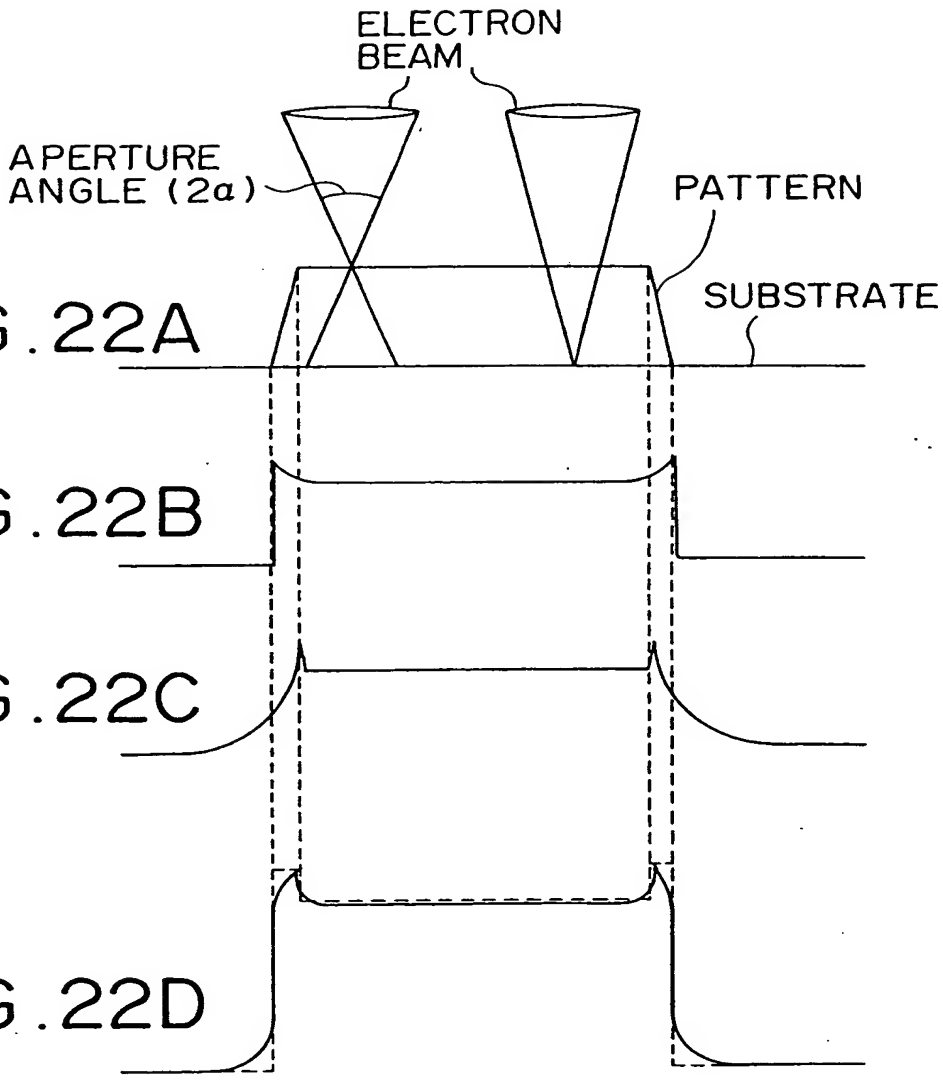


FIG. 22A

FIG. 22B

FIG. 22C

FIG. 22D

FIG.23

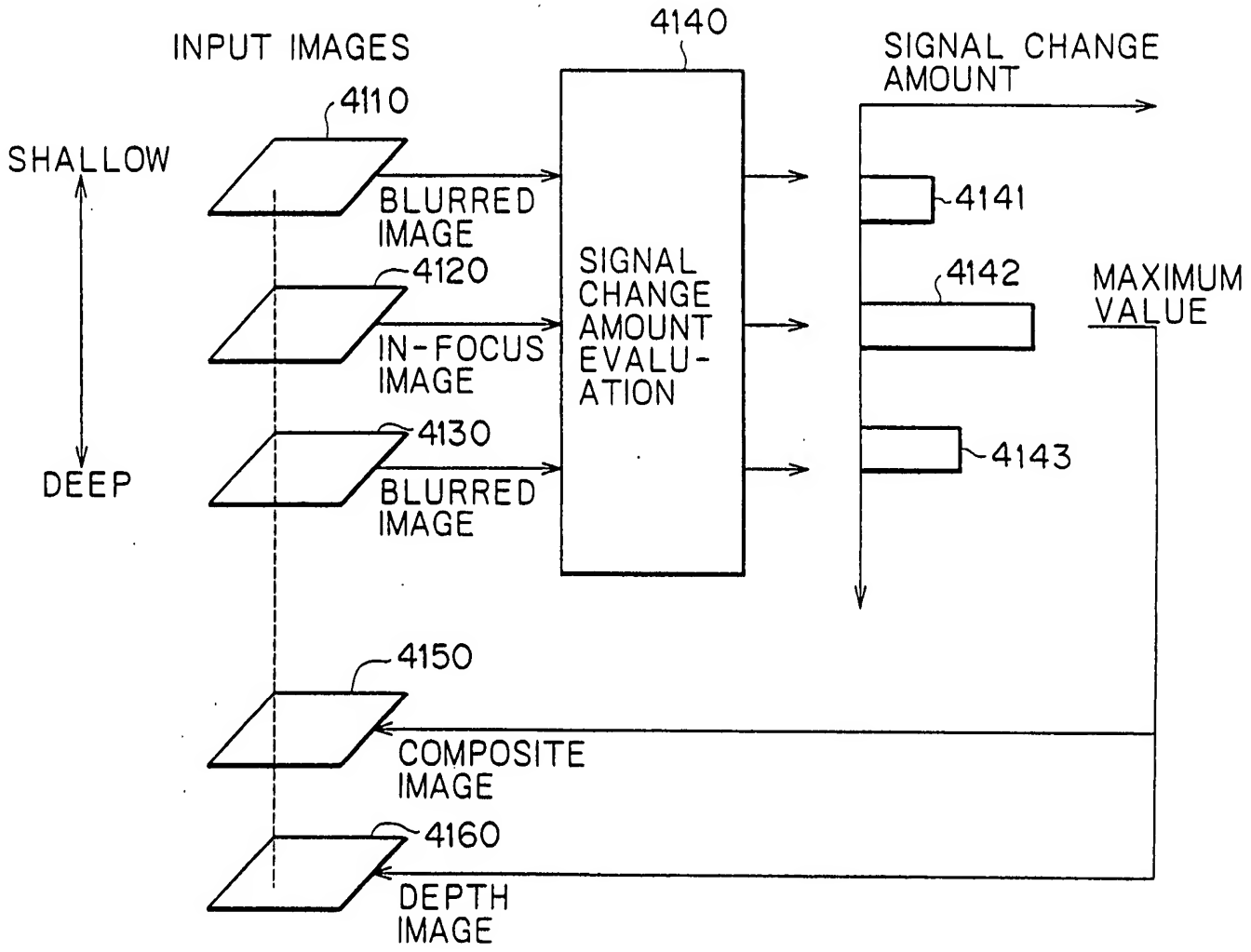

INPUT IMAGES
4140
SIGNAL CHANGE AMOUNT
4110
SHALLOW
BLURRED IMAGE
4141
4120
SIGNAL CHANGE AMOUNT EVALU-ATION
4142
MAXIMUM VALUE
IN-FOCUS IMAGE
4130
DEEP
BLURRED IMAGE
4143
4150
COMPOSITE IMAGE
4160
DEPTH IMAGE

FIG.24

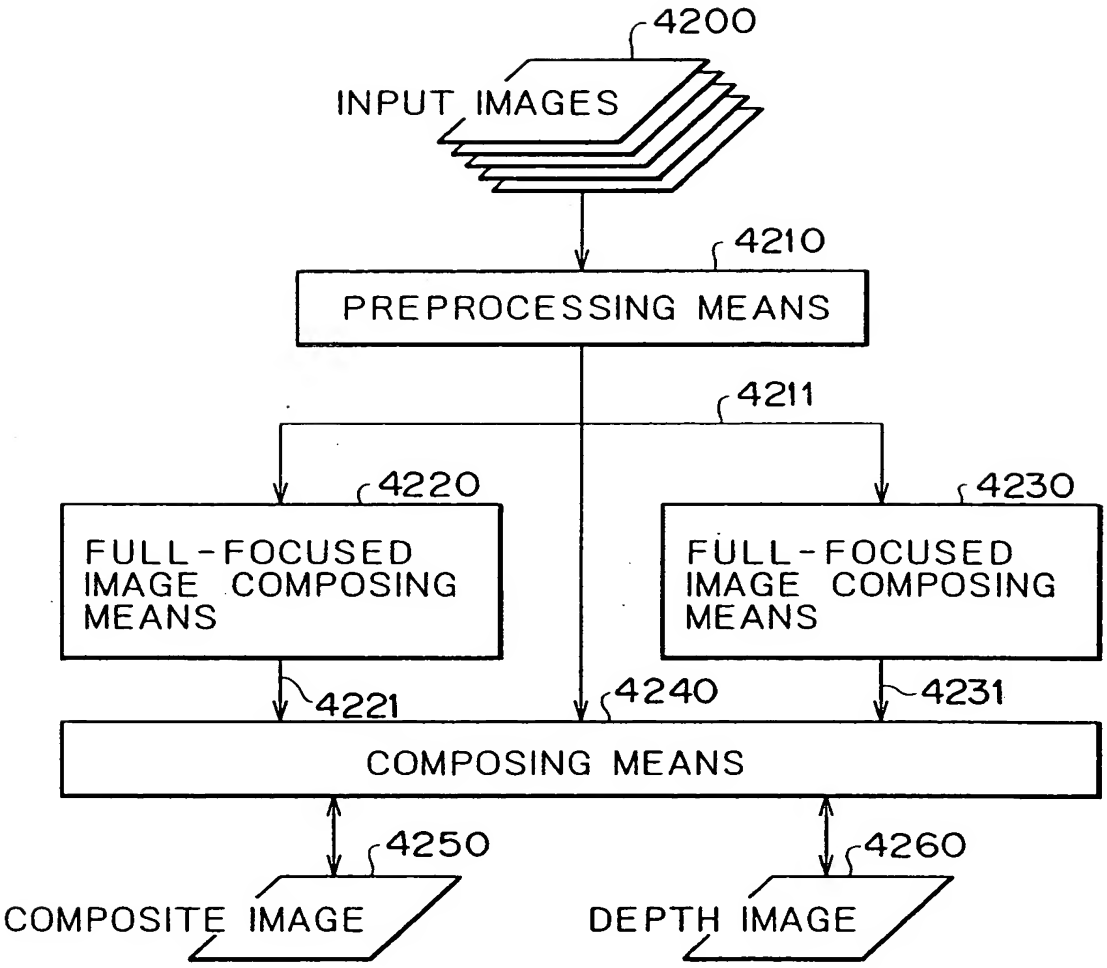

4200
INPUT IMAGES
4210
PREPROCESSING MEANS
4211
4220
FULL-FOCUSED IMAGE COMPOSING MEANS
4230
FULL-FOCUSED IMAGE COMPOSING MEANS
4221
4240
4231
COMPOSING MEANS
4250
4260
COMPOSITE IMAGE
DEPTH IMAGE

FIG. 25

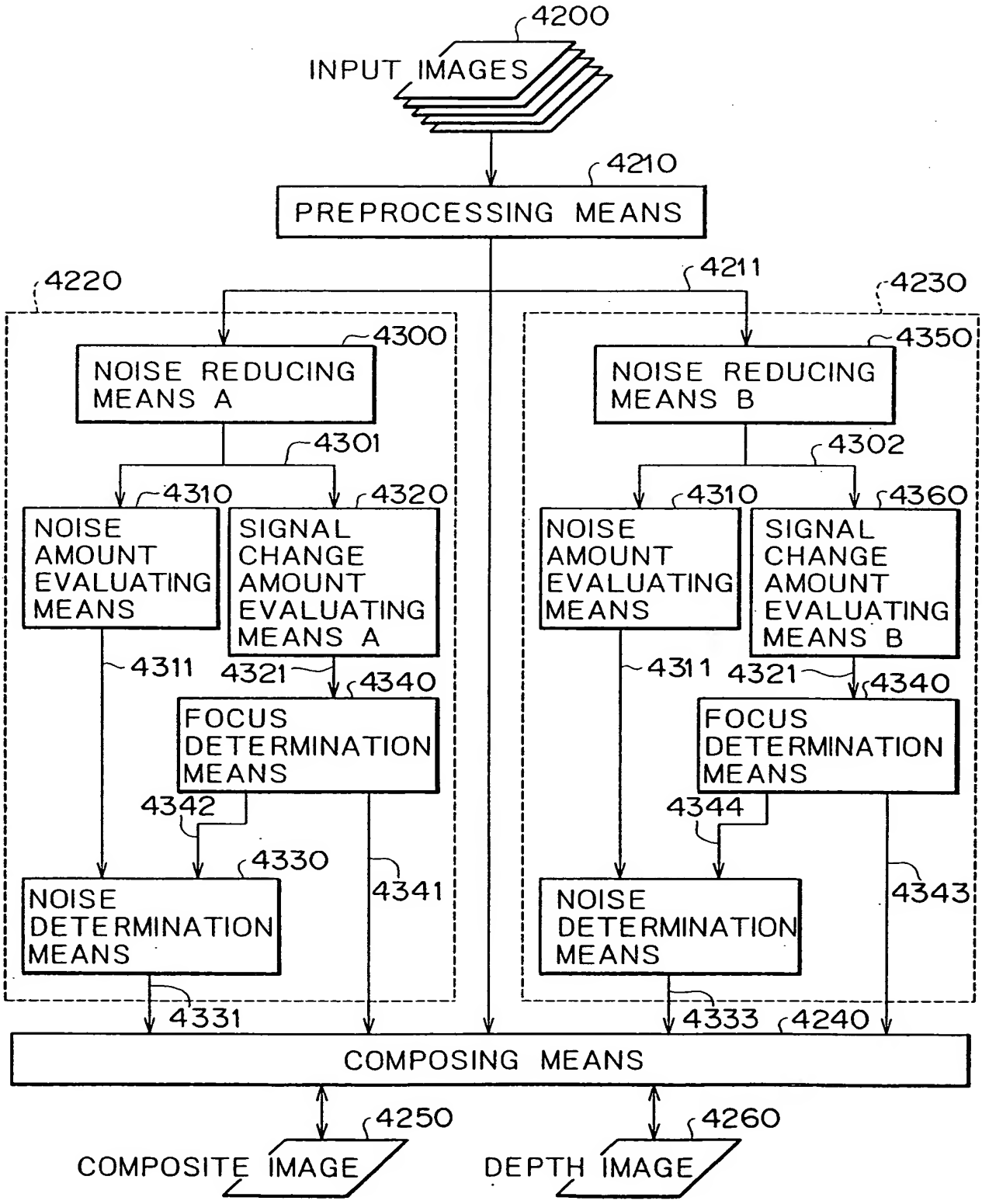

4200
INPUT IMAGES
4210
PREPROCESSING MEANS
4220
4211
4230
4300
NOISE REDUCING MEANS A
4350
NOISE REDUCING MEANS B
4301
4302
4310
4320
4310
4360
NOISE AMOUNT EVALUATING MEANS
SIGNAL CHANGE AMOUNT EVALUATING MEANS A
NOISE AMOUNT EVALUATING MEANS
SIGNAL CHANGE AMOUNT EVALUATING MEANS B
4311
4321
4340
4311
4321
4340
FOCUS DETERMINATION MEANS
FOCUS DETERMINATION MEANS
4342
4344
4330
4341
4343
NOISE DETERMINATION MEANS
NOISE DETERMINATION MEANS
4331
4333
4240
COMPOSING MEANS
4250
4260
COMPOSITE IMAGE
DEPTH IMAGE

FIG. 26

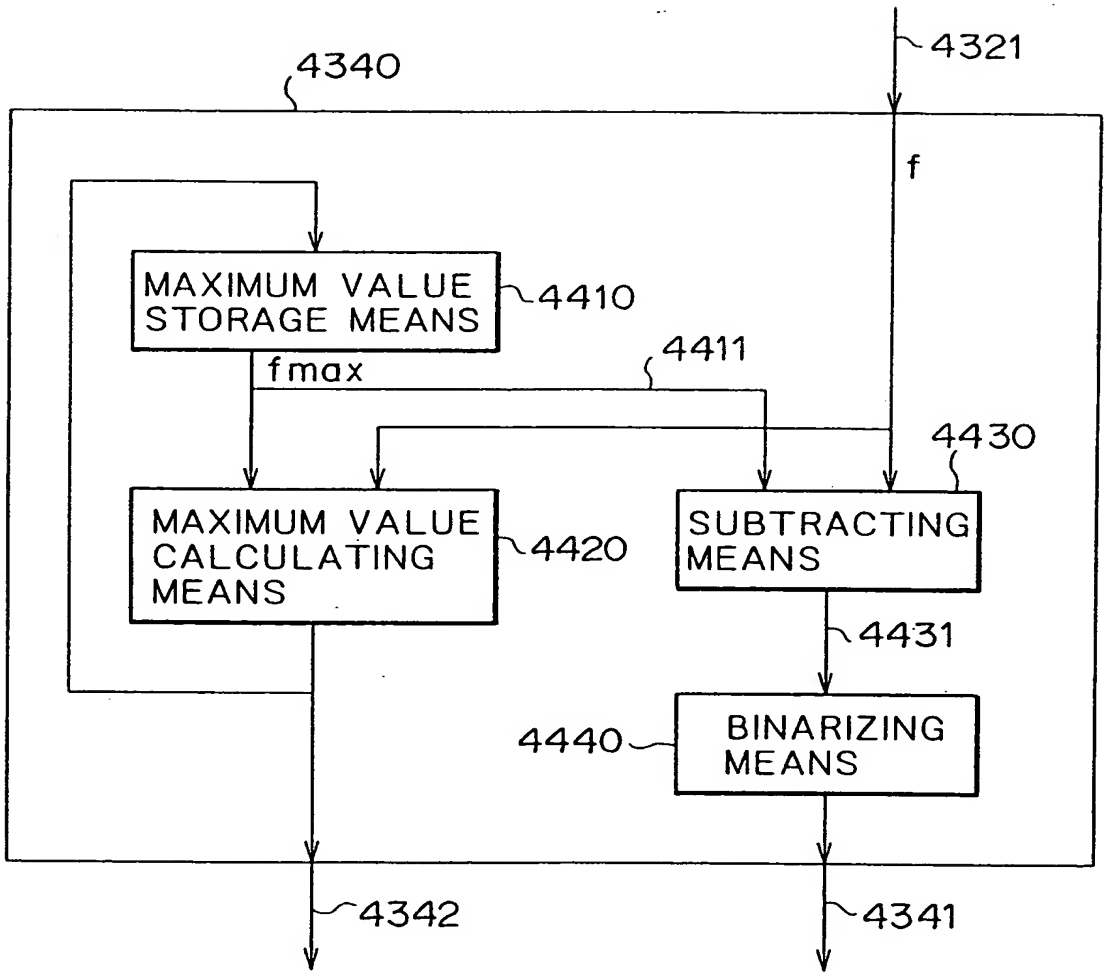

4340
4321
f
MAXIMUM VALUE STORAGE MEANS
4410
4411
fmax
4430
MAXIMUM VALUE CALCULATING MEANS
4420
SUBTRACTING MEANS
4431
4440
BINARIZING MEANS
4342
4341

FIG. 27

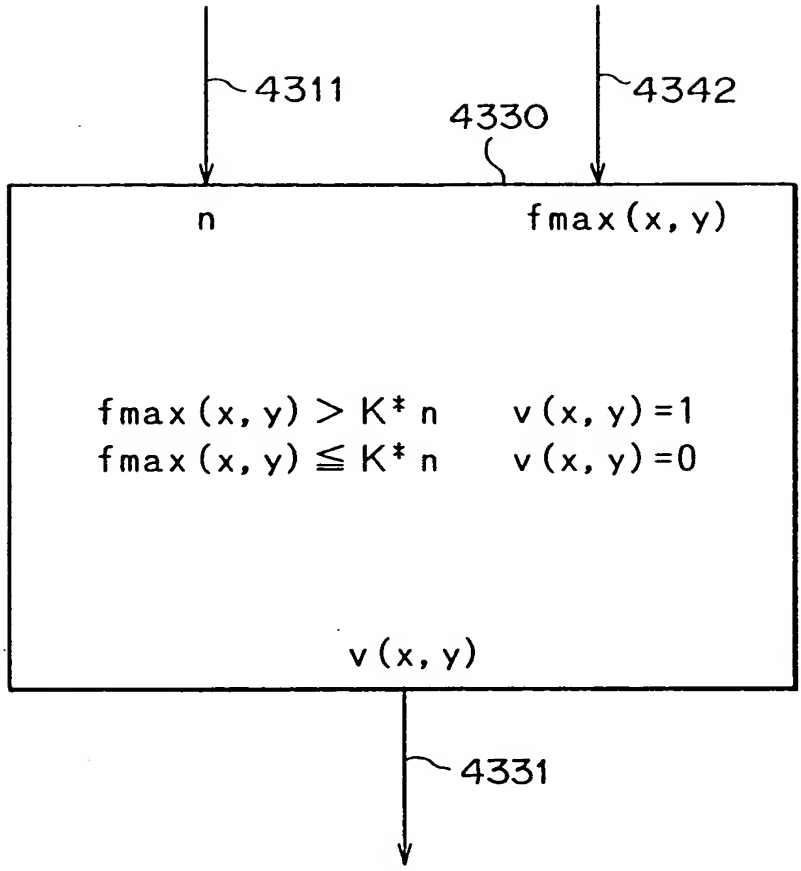
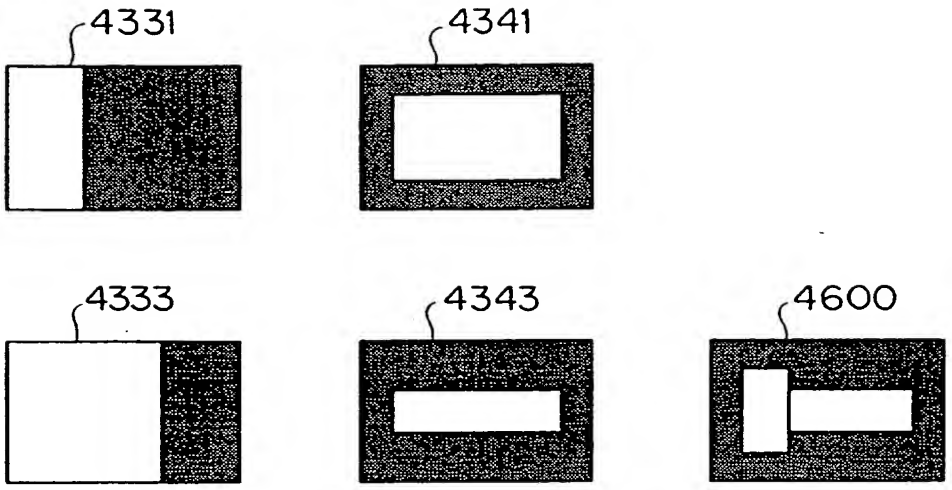

4311
4330
4342
n
fmax(x, y)
fmax(x, y) > K* n
v(x, y) =1
fmax(x, y) ≦ K* n
v(x, y) =0
v(x, y)
4331

FIG.28



4331	4333	4341	4343	4250	4260
1	—	1	—	4211	DEPTH INFORMATION ABOUT 4211
1	—	0	—	4250	4260
0	1	—	1	4211	DEPTH INFORMATION ABOUT 4211
0	1	—	0	4250	4260
0	0	—	1	4211	DEPTH INFORMATION ABOUT 4211
0	0	—	0	4250	4260

FIG. 29

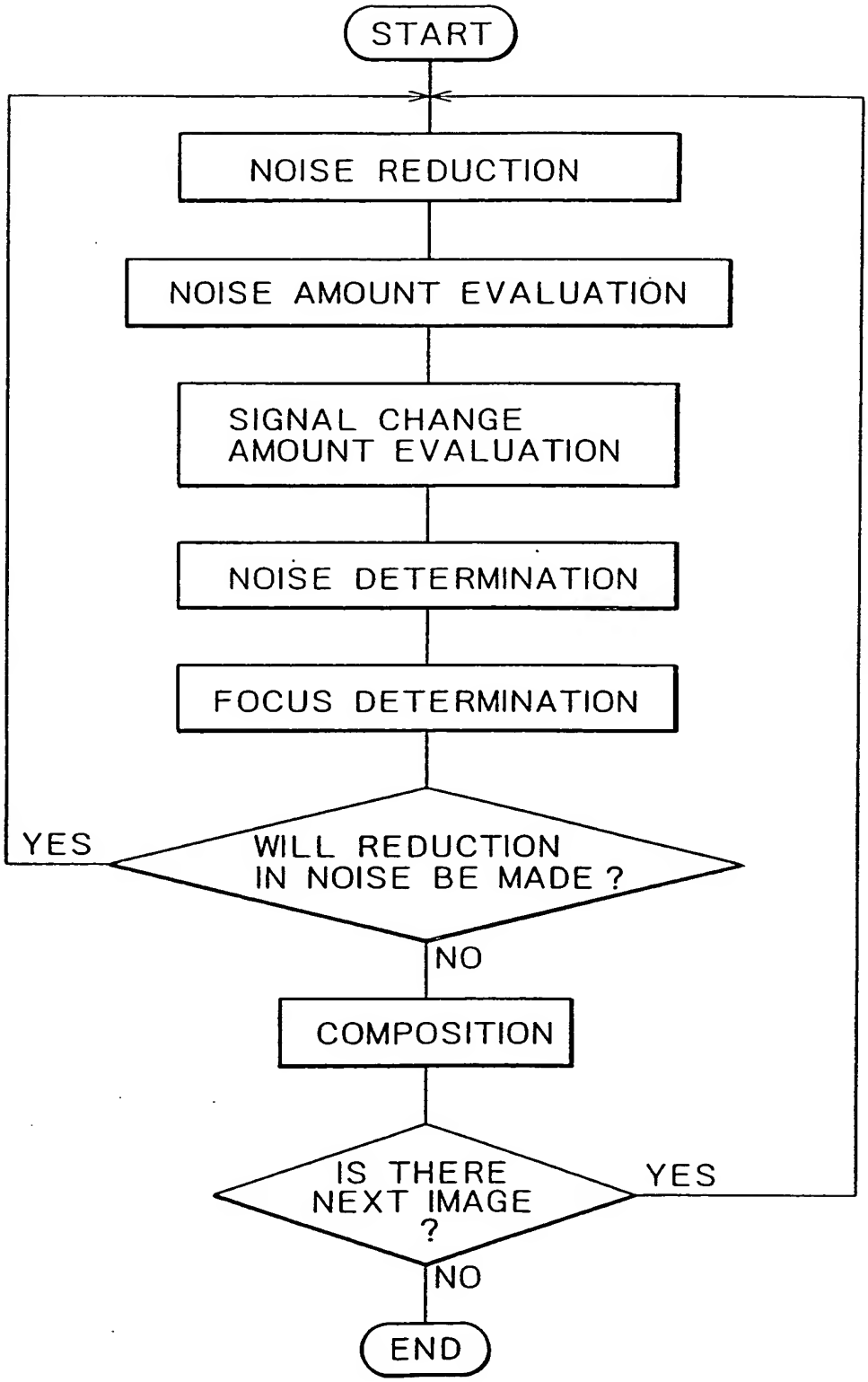

START
NOISE REDUCTION
NOISE AMOUNT EVALUATION
SIGNAL CHANGE AMOUNT EVALUATION
NOISE DETERMINATION
FOCUS DETERMINATION
WILL REDUCTION IN NOISE BE MADE ?
YES
NO
COMPOSITION
IS THERE NEXT IMAGE ?
YES
NO
END

FIG. 30

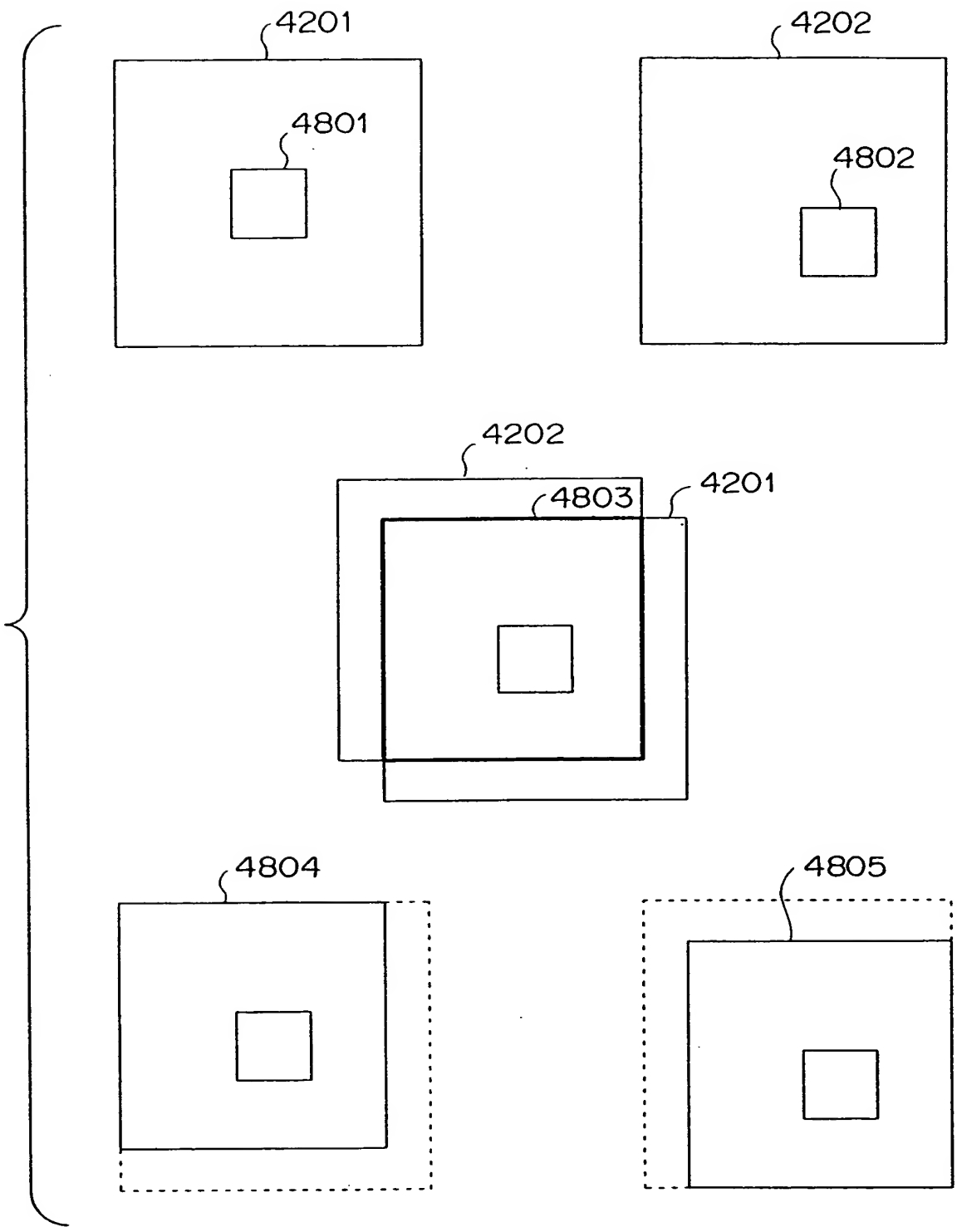


FIG.31

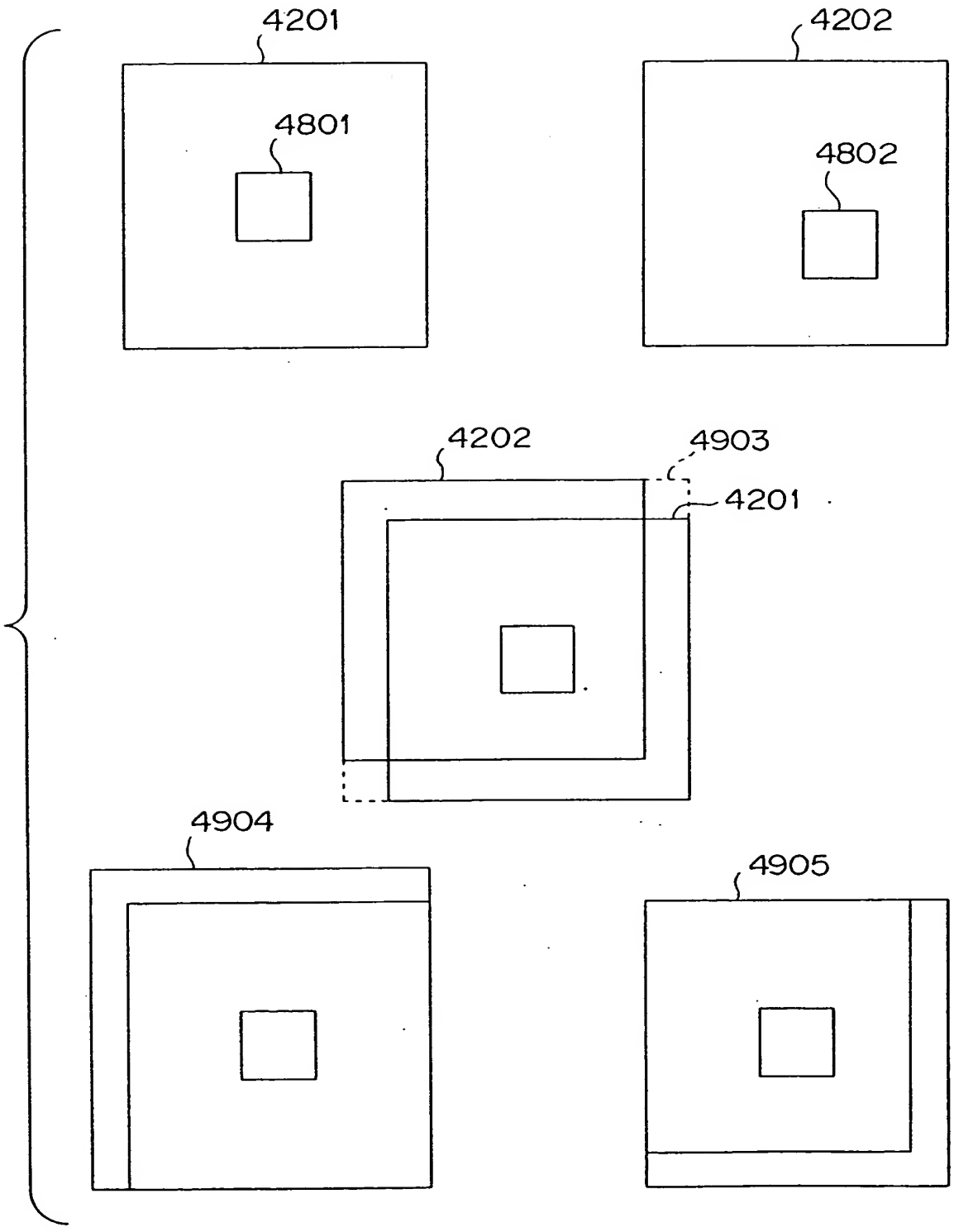


FIG.32

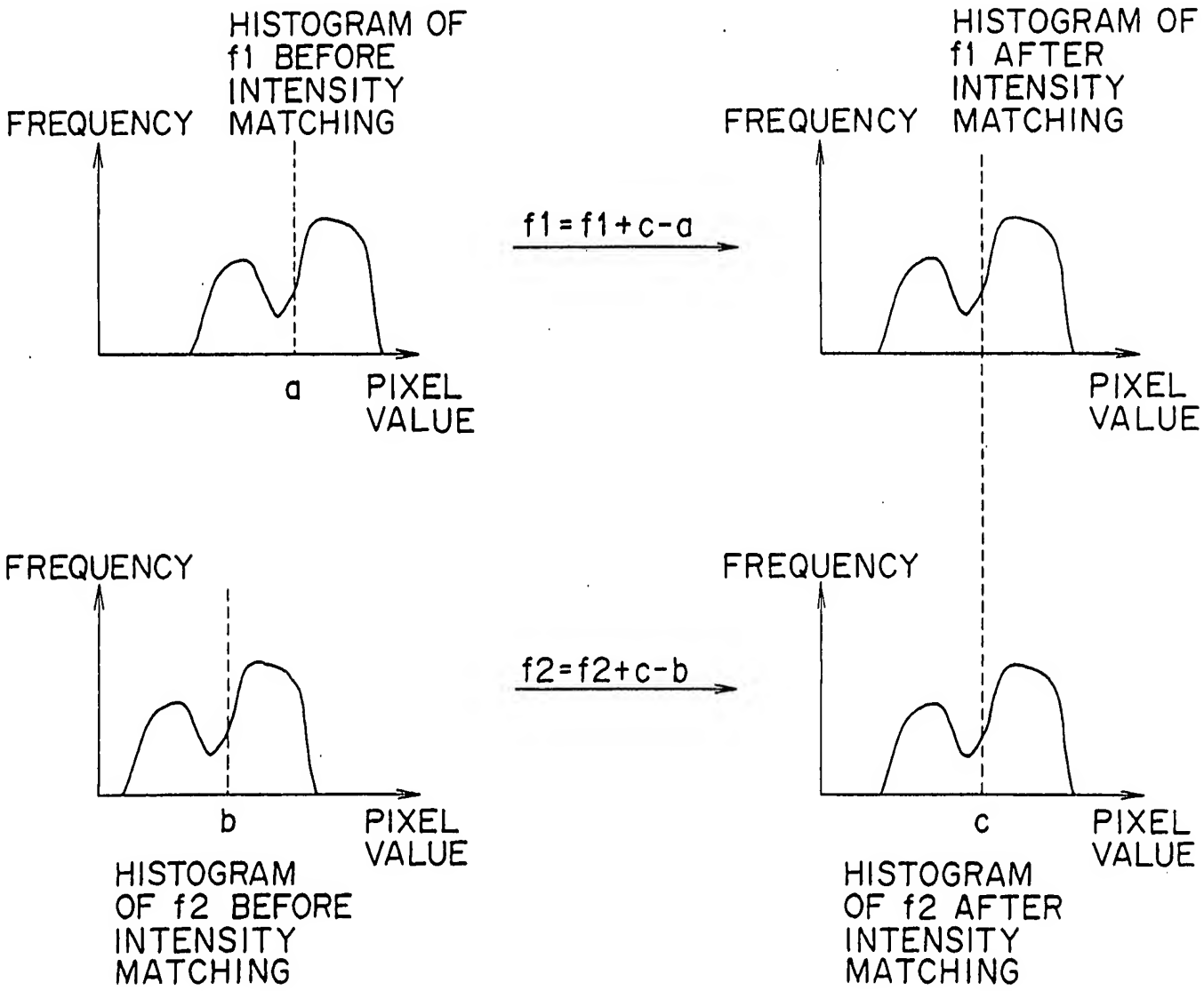

HISTOGRAM OF f1 BEFORE INTENSITY MATCHING
FREQUENCY
a
PIXEL VALUE
f1=f1+c-a
HISTOGRAM OF f1 AFTER INTENSITY MATCHING
FREQUENCY
PIXEL VALUE
FREQUENCY
b
PIXEL VALUE
HISTOGRAM OF f2 BEFORE INTENSITY MATCHING
f2=f2+c-b
FREQUENCY
c
PIXEL VALUE
HISTOGRAM OF f2 AFTER INTENSITY MATCHING

FIG. 33

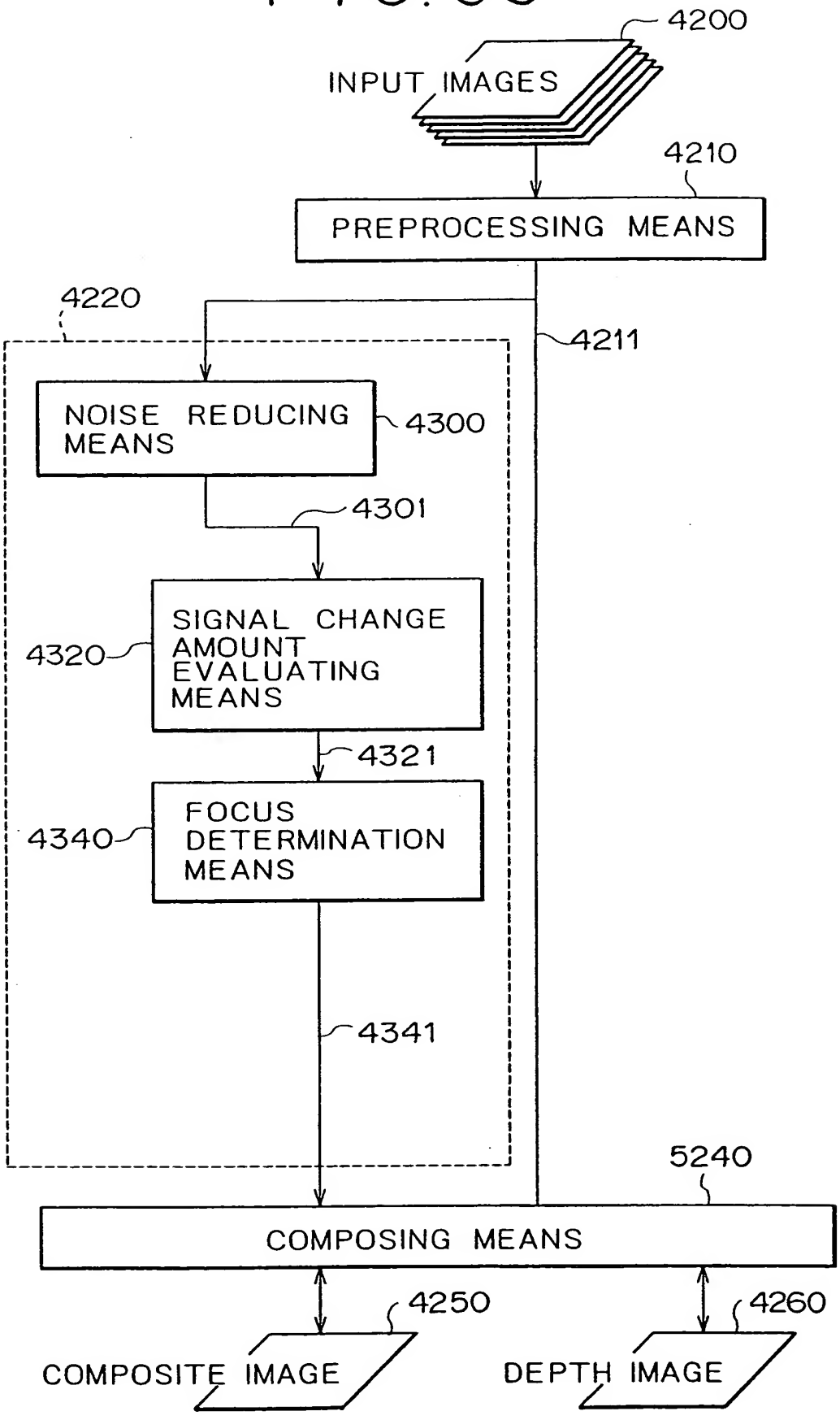

4200
INPUT IMAGES
4210
PREPROCESSING MEANS
4220
4211
NOISE REDUCING MEANS
4300
4301
SIGNAL CHANGE AMOUNT EVALUATING MEANS
4320
4321
FOCUS DETERMINATION MEANS
4340
4341
5240
COMPOSING MEANS
4250
COMPOSITE IMAGE
4260
DEPTH IMAGE

FIG. 34

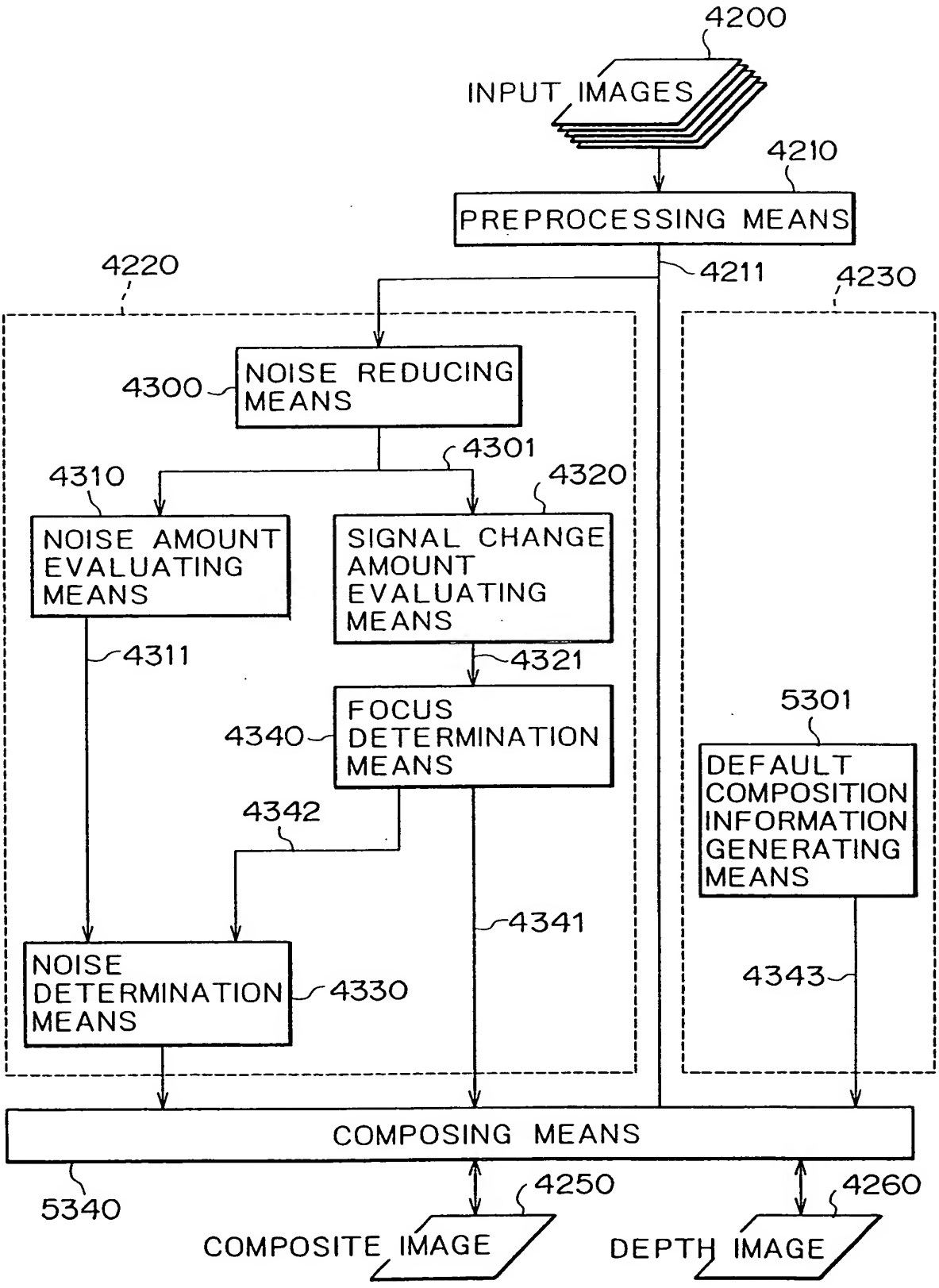

4200
INPUT IMAGES
4210
PREPROCESSING MEANS
4220
4211
4230
4300
NOISE REDUCING MEANS
4301
4310
4320
NOISE AMOUNT EVALUATING MEANS
SIGNAL CHANGE AMOUNT EVALUATING MEANS
4311
4321
5301
4340
FOCUS DETERMINATION MEANS
DEFAULT COMPOSITION INFORMATION GENERATING MEANS
4342
4341
4343
NOISE DETERMINATION MEANS
4330
COMPOSING MEANS
5340
4250
4260
COMPOSITE IMAGE
DEPTH IMAGE

FIG. 35

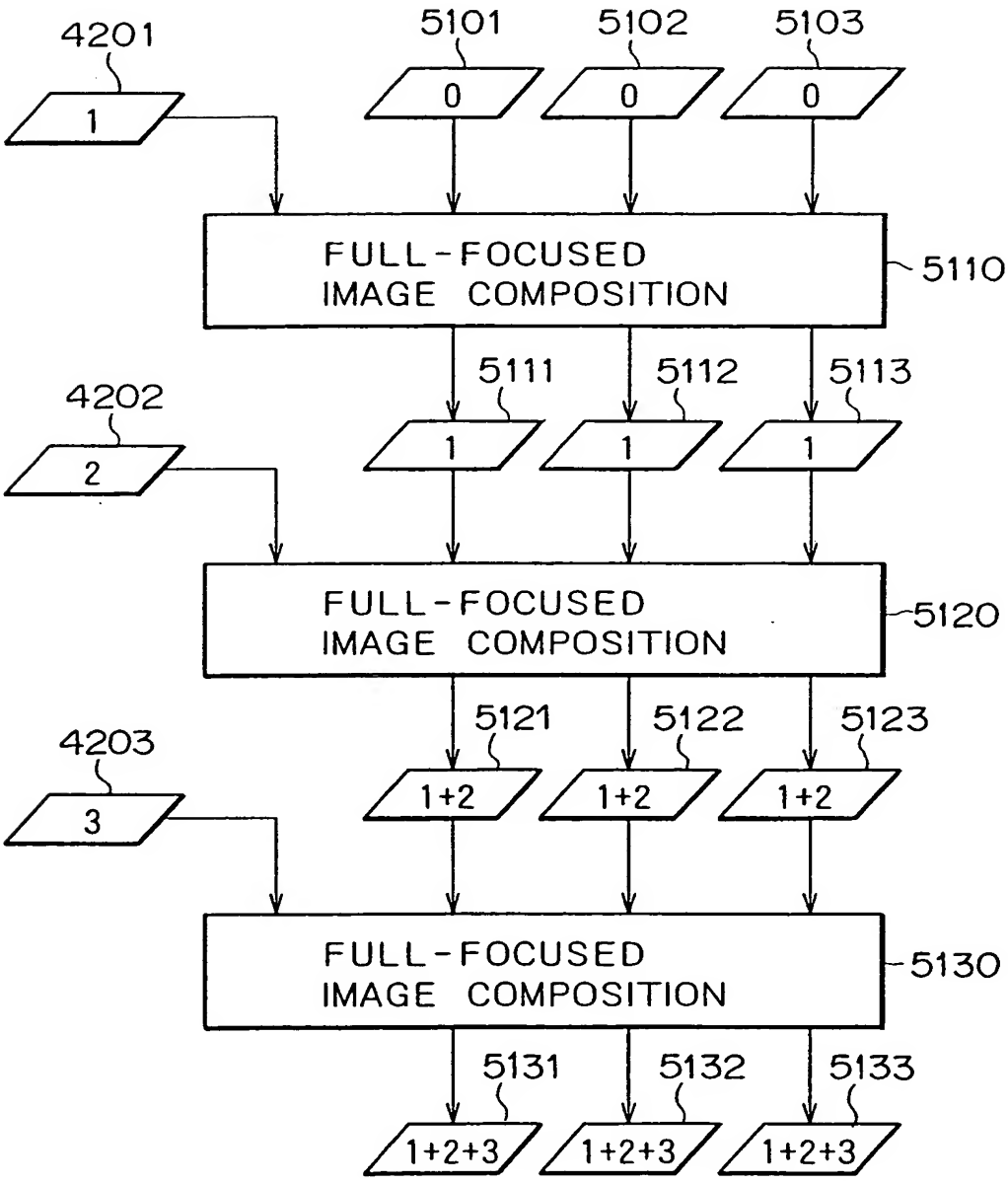

4201
1
5101
5102
5103
0
0
0
FULL-FOCUSED IMAGE COMPOSITION
5110
5111
5112
5113
4202
2
1
1
1
FULL-FOCUSED IMAGE COMPOSITION
5120
5121
5122
5123
4203
3
1+2
1+2
1+2
FULL-FOCUSED IMAGE COMPOSITION
5130
5131
5132
5133
1+2+3
1+2+3
1+2+3

FIG. 36

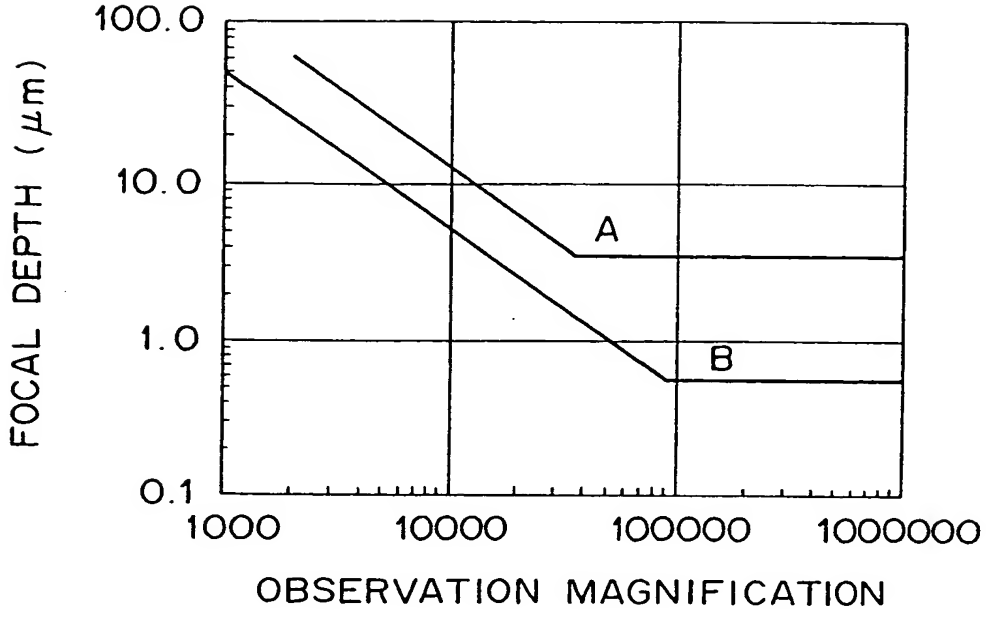

100.0
10.0
1.0
0.1
FOCAL DEPTH (μm)
A
B
1000
10000
100000
1000000
OBSERVATION MAGNIFICATION

FIG. 37

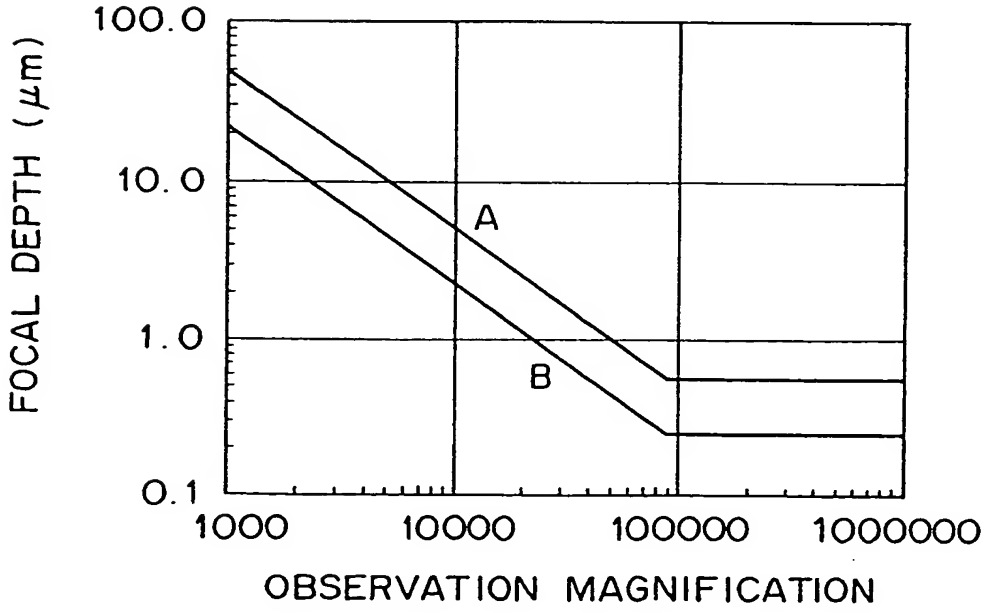

100.0
10.0
1.0
0.1
FOCAL DEPTH (μm)
A
B
1000
10000
100000
1000000
OBSERVATION MAGNIFICATION

FIG. 38

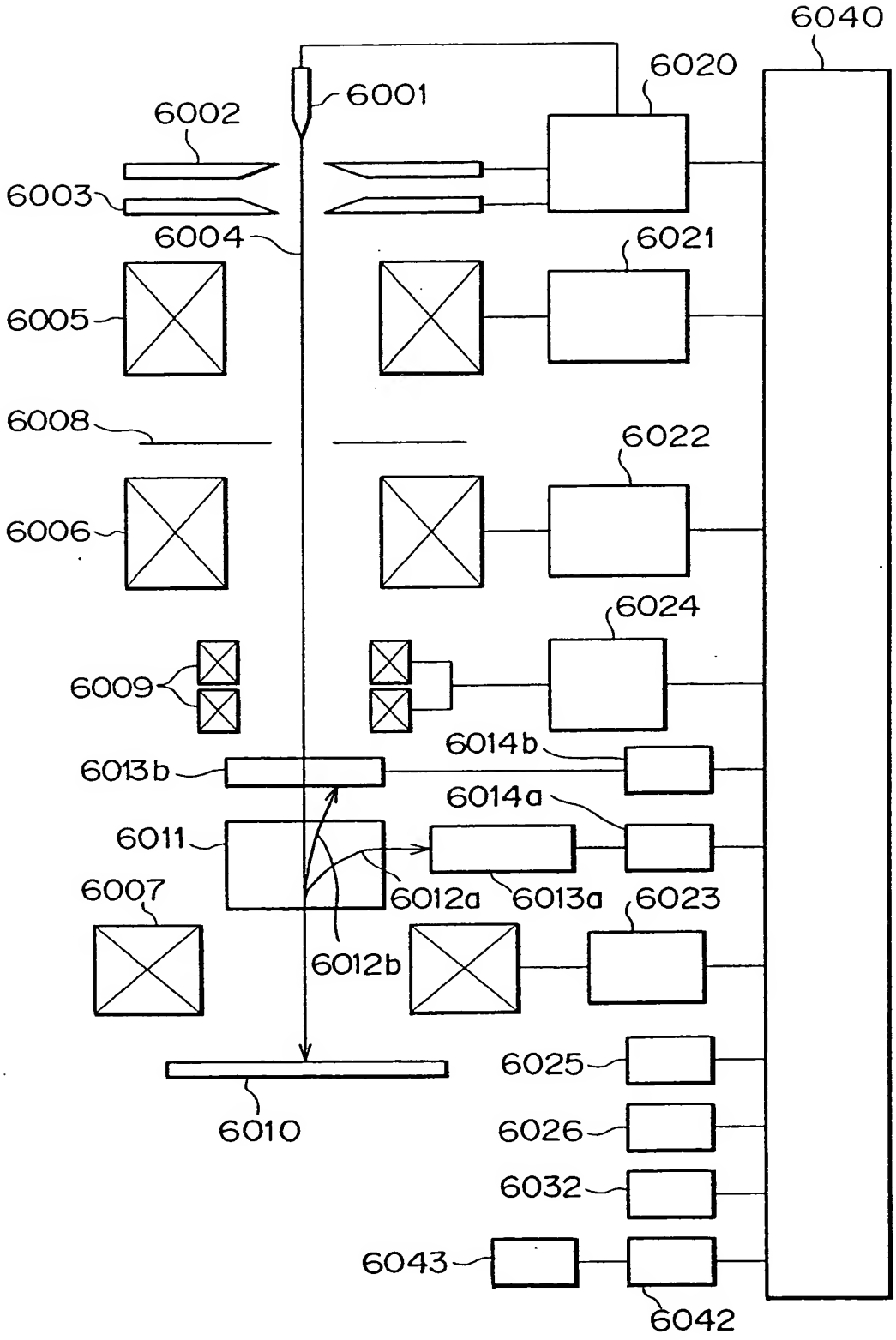

6040
6020
6001
6002
6003
6004
6021
6005
6008
6022
6006
6024
6009
6014b
6013b
6014a
6011
6012a
6013a
6023
6007
6012b
6025
6010
6026
6032
6043
6042

FIG. 39

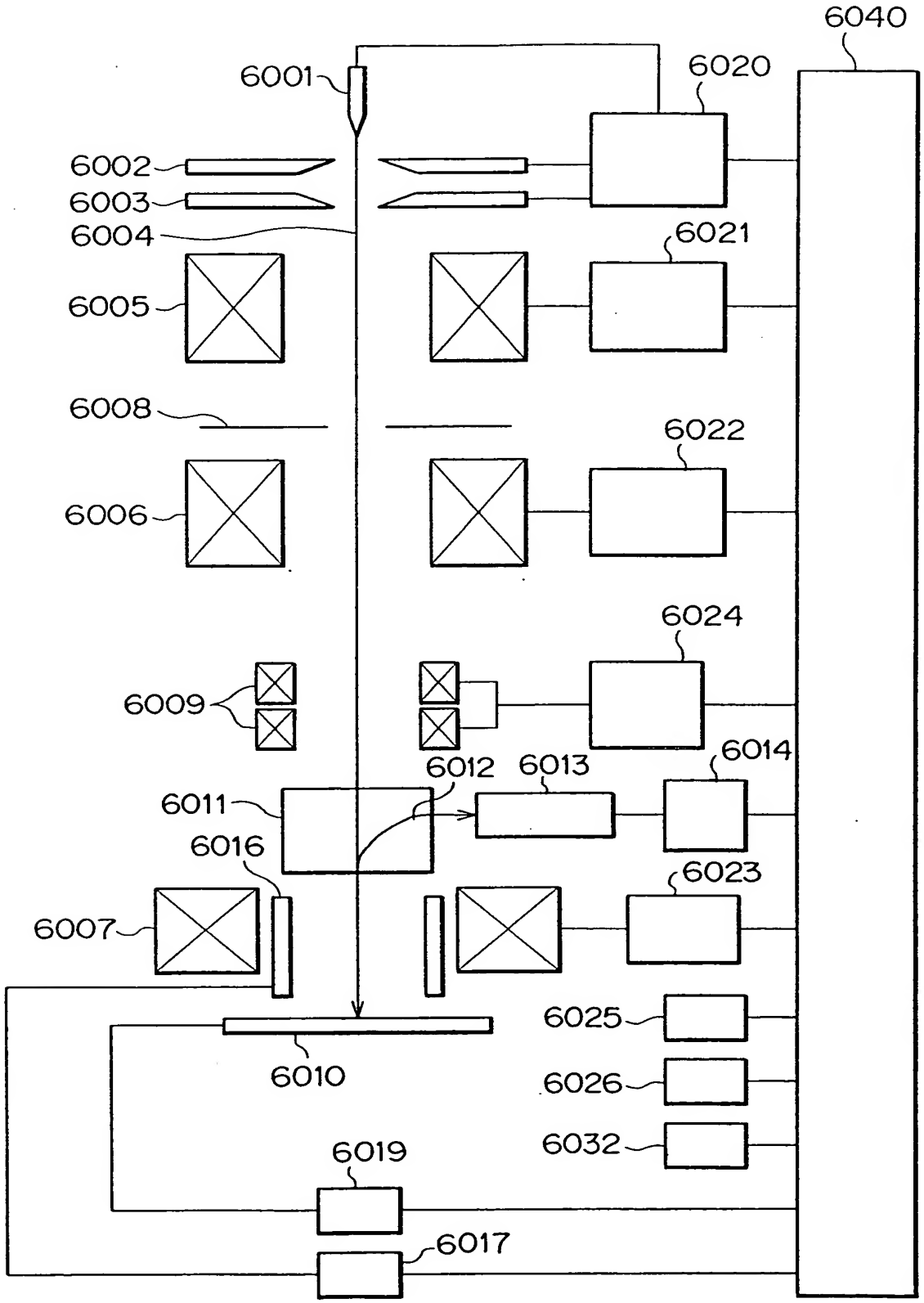

6040
6001
6020
6002
6003
6004
6021
6005
6008
6022
6006
6024
6009
6012
6013
6014
6011
6016
6023
6007
6025
6010
6026
6032
6019
6017

FIG. 40

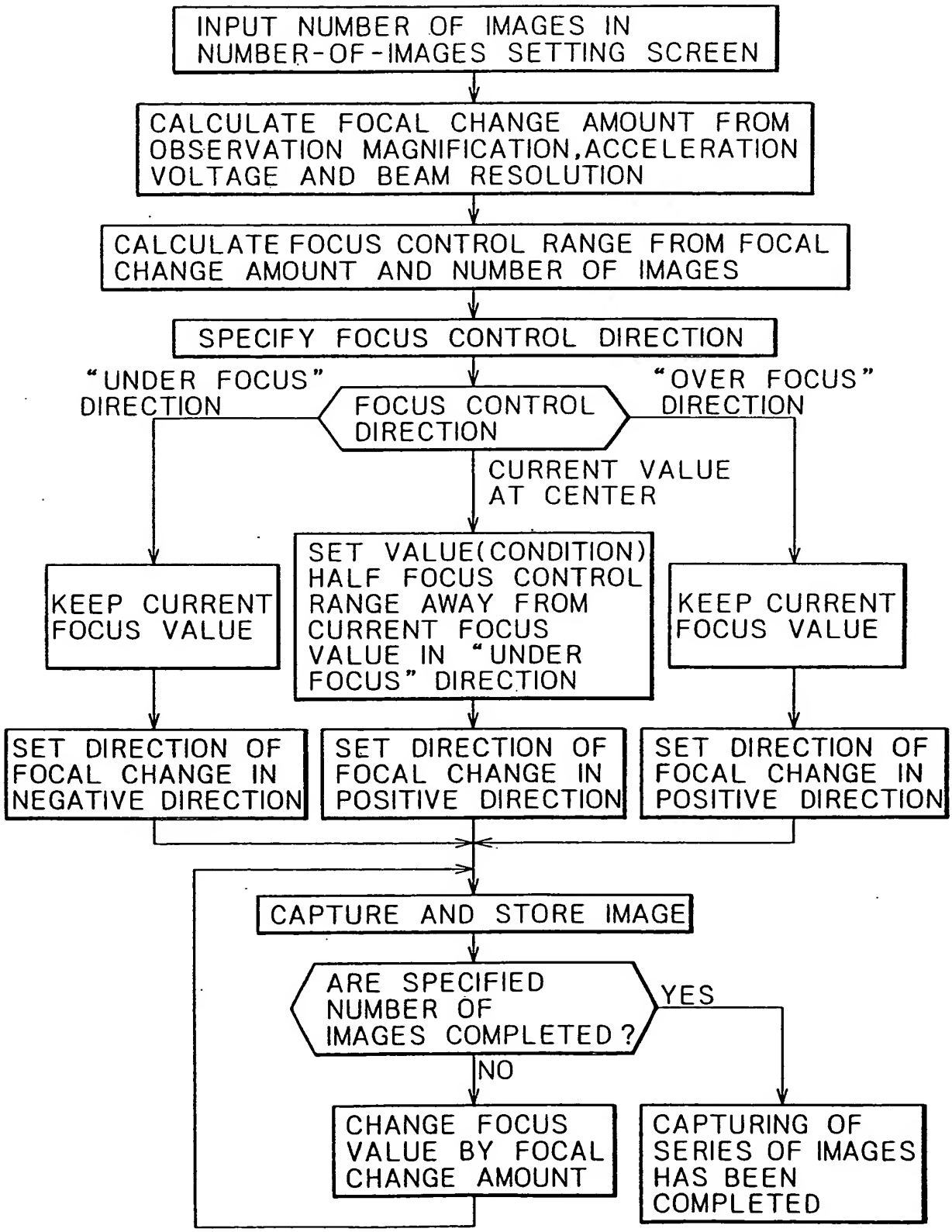

INPUT NUMBER OF IMAGES IN NUMBER-OF-IMAGES SETTING SCREEN
CALCULATE FOCAL CHANGE AMOUNT FROM OBSERVATION MAGNIFICATION, ACCELERATION VOLTAGE AND BEAM RESOLUTION
CALCULATE FOCUS CONTROL RANGE FROM FOCAL CHANGE AMOUNT AND NUMBER OF IMAGES
SPECIFY FOCUS CONTROL DIRECTION
"UNDER FOCUS" DIRECTION
FOCUS CONTROL DIRECTION
"OVER FOCUS" DIRECTION
CURRENT VALUE AT CENTER
KEEP CURRENT FOCUS VALUE
SET VALUE(CONDITION) HALF FOCUS CONTROL RANGE AWAY FROM CURRENT FOCUS VALUE IN "UNDER FOCUS" DIRECTION
KEEP CURRENT FOCUS VALUE
SET DIRECTION OF FOCAL CHANGE IN NEGATIVE DIRECTION
SET DIRECTION OF FOCAL CHANGE IN POSITIVE DIRECTION
SET DIRECTION OF FOCAL CHANGE IN POSITIVE DIRECTION
CAPTURE AND STORE IMAGE
ARE SPECIFIED NUMBER OF IMAGES COMPLETED ?
YES
NO
CHANGE FOCUS VALUE BY FOCAL CHANGE AMOUNT
CAPTURING OF SERIES OF IMAGES HAS BEEN COMPLETED

FIG. 41

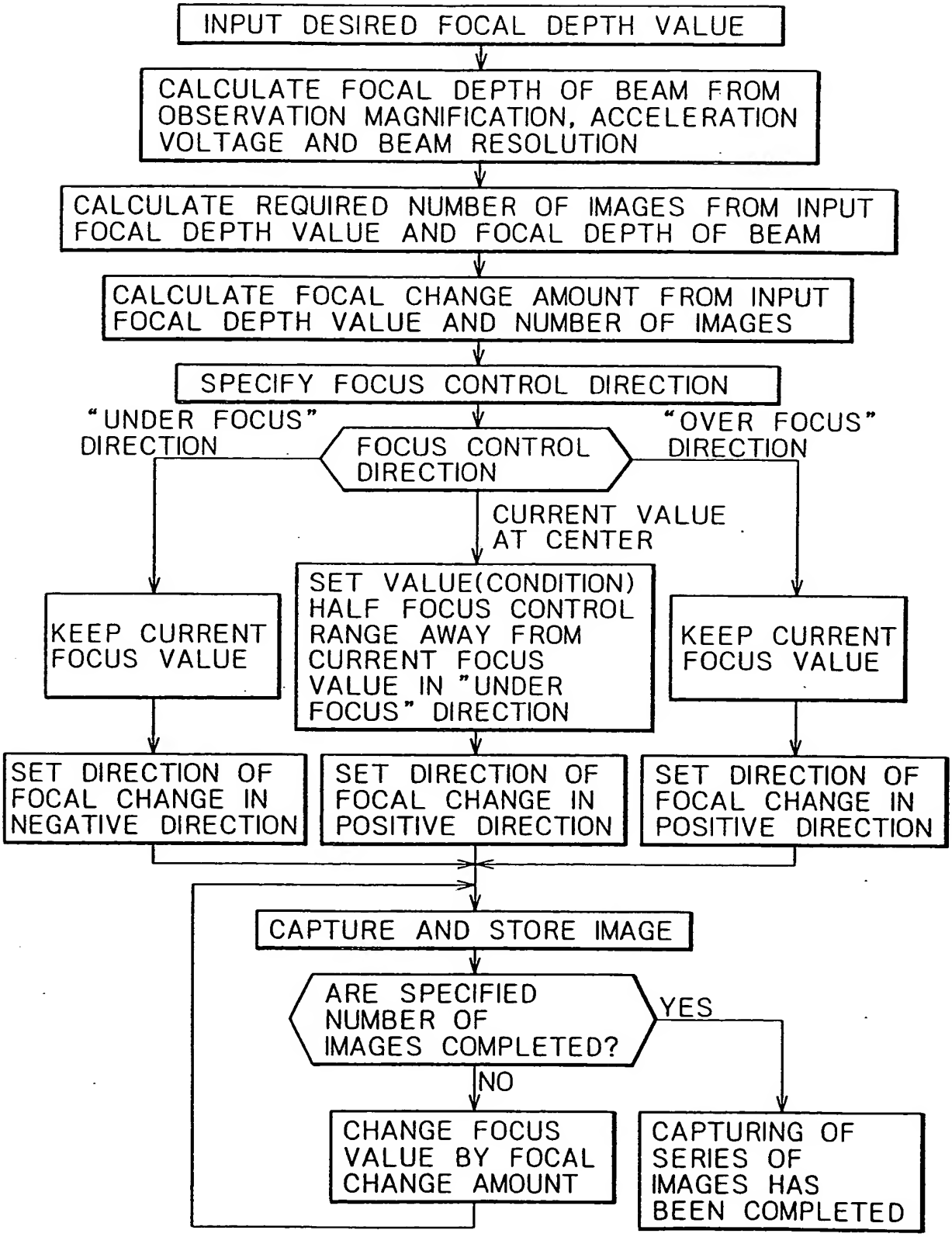
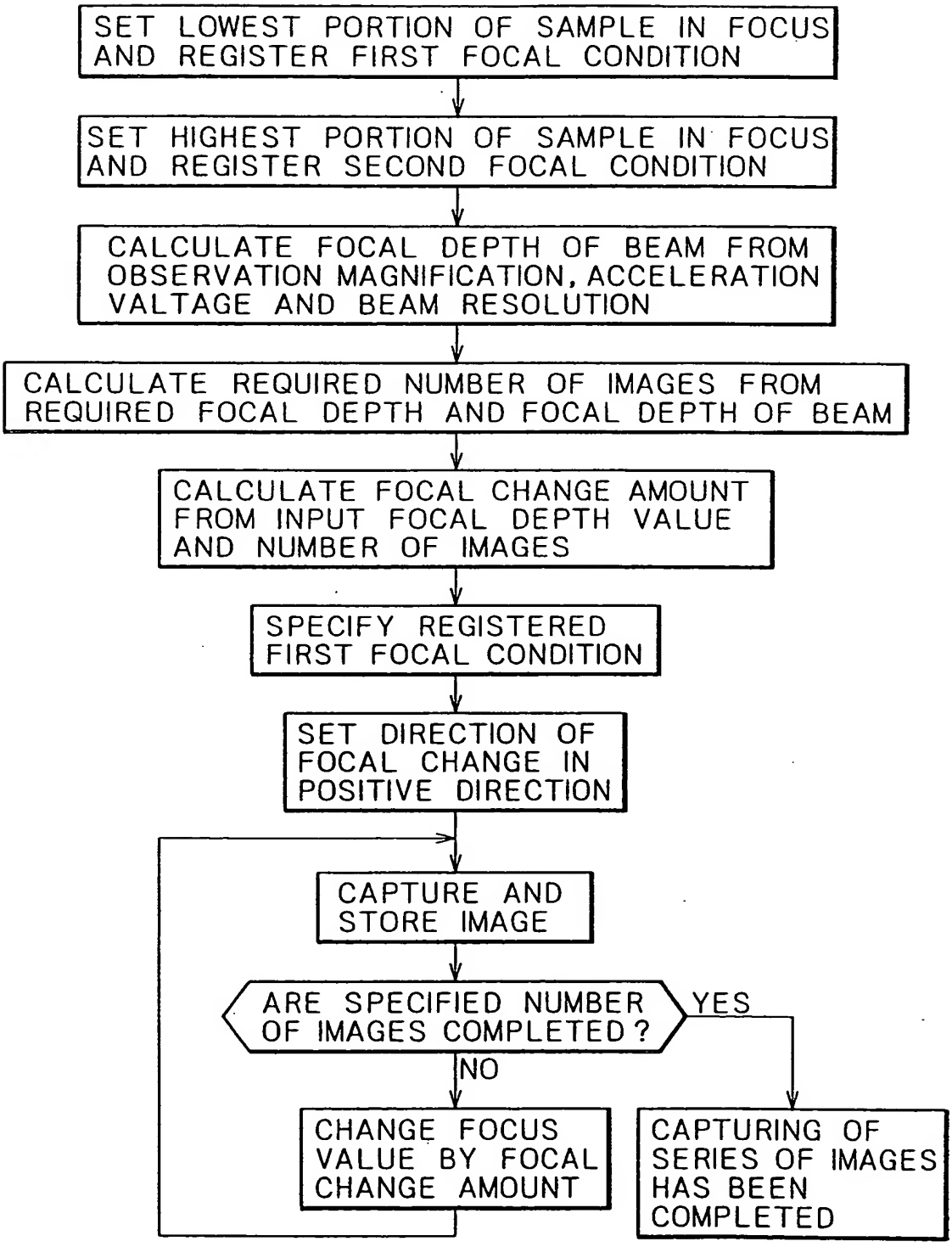

INPUT DESIRED FOCAL DEPTH VALUE
CALCULATE FOCAL DEPTH OF BEAM FROM OBSERVATION MAGNIFICATION, ACCELERATION VOLTAGE AND BEAM RESOLUTION
CALCULATE REQUIRED NUMBER OF IMAGES FROM INPUT FOCAL DEPTH VALUE AND FOCAL DEPTH OF BEAM
CALCULATE FOCAL CHANGE AMOUNT FROM INPUT FOCAL DEPTH VALUE AND NUMBER OF IMAGES
SPECIFY FOCUS CONTROL DIRECTION
"UNDER FOCUS" DIRECTION
FOCUS CONTROL DIRECTION
"OVER FOCUS" DIRECTION
CURRENT VALUE AT CENTER
KEEP CURRENT FOCUS VALUE
SET VALUE(CONDITION) HALF FOCUS CONTROL RANGE AWAY FROM CURRENT FOCUS VALUE IN "UNDER FOCUS" DIRECTION
KEEP CURRENT FOCUS VALUE
SET DIRECTION OF FOCAL CHANGE IN NEGATIVE DIRECTION
SET DIRECTION OF FOCAL CHANGE IN POSITIVE DIRECTION
SET DIRECTION OF FOCAL CHANGE IN POSITIVE DIRECTION
CAPTURE AND STORE IMAGE
ARE SPECIFIED NUMBER OF IMAGES COMPLETED?
YES
NO
CHANGE FOCUS VALUE BY FOCAL CHANGE AMOUNT
CAPTURING OF SERIES OF IMAGES HAS BEEN COMPLETED

FIG. 42


SET LOWEST PORTION OF SAMPLE IN FOCUS AND REGISTER FIRST FOCAL CONDITION
SET HIGHEST PORTION OF SAMPLE IN FOCUS AND REGISTER SECOND FOCAL CONDITION
CALCULATE FOCAL DEPTH OF BEAM FROM OBSERVATION MAGNIFICATION, ACCELERATION VALTAGE AND BEAM RESOLUTION
CALCULATE REQUIRED NUMBER OF IMAGES FROM REQUIRED FOCAL DEPTH AND FOCAL DEPTH OF BEAM
CALCULATE FOCAL CHANGE AMOUNT FROM INPUT FOCAL DEPTH VALUE AND NUMBER OF IMAGES
SPECIFY REGISTERED FIRST FOCAL CONDITION
SET DIRECTION OF FOCAL CHANGE IN POSITIVE DIRECTION
CAPTURE AND STORE IMAGE
ARE SPECIFIED NUMBER OF IMAGES COMPLETED?
YES
NO
CHANGE FOCUS VALUE BY FOCAL CHANGE AMOUNT
CAPTURING OF SERIES OF IMAGES HAS BEEN COMPLETED